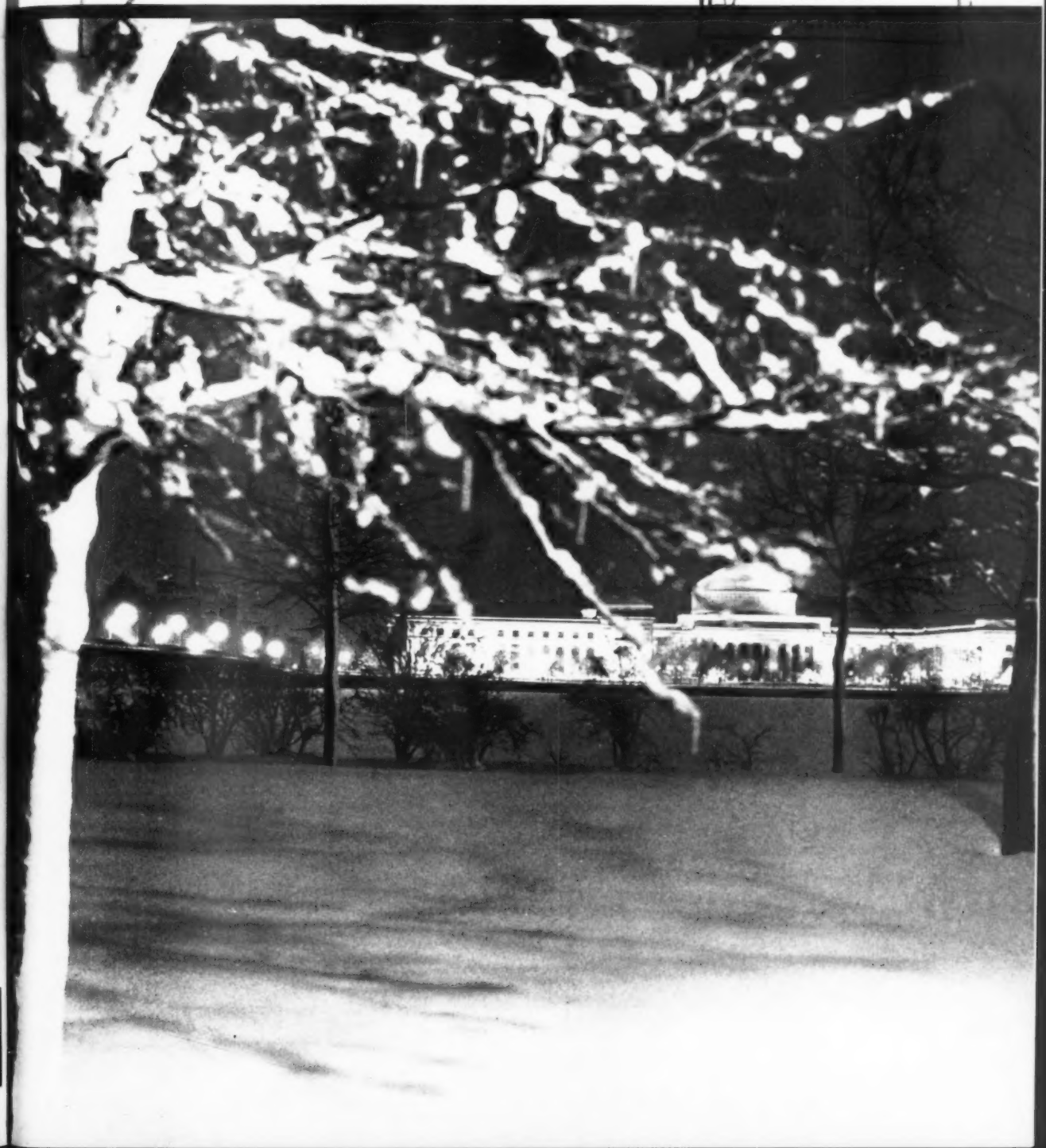
OLOGY DEPARTMENT

February 1947

TECHNOLOGY REVIEW

Title Reg. in U. S. Pat. Office

PUBLIC LIBRARY
FEB 7 - 1947
DETROIT



FOR LOWER COSTS AT POINTS OF ASSEMBL

THE HARVEY METAL CORPORATION

HAROLD S. HARVEY '05 • *Engineers & Manufacturers* • SHERRY O'BRIEN '17

74th STREET and ASHLAND AVENUE • CHICAGO 36, ILLINOIS

FORGINGS IN ALUMINUM • BRASS • BRONZE • COPPER • MAGNESIUM • MONEL • ALLOY

MACHINING FACILITIES

MBL

Safety Goggles Win High Praise from Gem Safety Razor Corporation

"This A-O Goggle saved the eye and possibly the life of E. Steller of the Brush Department. This chip in the lens was caused by the tool-bit he holds in his hand."

Typical records reveal that eye injuries cost (in first aid attention, idle machine charges, unproductive time and other frequently "hidden costs") $14.60 per injured man per year. Yet 98% of these accidents (according to the verified figures of the National Society for the Prevention of Blindness) are *avoidable*—mainly through the use of Safety Goggles.

Can you afford to overlook this opportunity to lower your production costs?

Send to your nearest A-O Safety Representative or direct to American Optical Company, Box T for a copy of the new book, "Eye Accident Costs," telling how to prevent them and how much you can save by preventing them.

American Optical Company
Safety Division

SOUTHBRIDGE, MASSACHUSETTS
BRANCHES IN PRINCIPAL CITIES

THE TECHNOLOGY REVIEW, February, 1947. Vol. XLIX, No. 4. Published monthly from November to July inclusive at 10 Ferry Street, Concord, N. H. Publication date: twenty-seventh of the month preceding date of issue. Annual subscription $3.50; Canadian and Foreign subscription $4.00. Entered as second-class matter at the Post Office at Concord, N. H., under the Act of March 3, 1879.
NEWSSTAND EDITION

FROM "CRACKING" IN CHUNGKING TO COKING IN CHICAGO

...LUMMUS has acquired a world of refining know-how

From here to China . . . from Venezuela to the U.S.S.R. . . . more than 600 Lummus-built petroleum and chemical plants are delivering high yields of high-quality products. In designing, constructing, and supervising the initial operation of all these plants, Lummus literally has acquired a world of practical experience in every phase of petroleum refining.

Many Lummus-built plants have established records for *long initial runs* – the forerunners of *outstanding performance in the long run.*

Whatever direction your refinery plans are taking, Lummus has the know-how – plus the laboratory, pilot-plant, engineering, and construction facilities – to help translate them into profits. Lummus engineers will appreciate an opportunity to discuss the desirability of studying your refinery, to determine what modernization or expansion will be necessary to meet tomorrow's market requirements.

THE LUMMUS COMPANY
420 Lexington Avenue, New York 17, N. Y.
CHICAGO – 600 South Michigan Avenue, Chicago 5, Illinois
HOUSTON – Mellie Esperson Building, Houston 2, Texas
LONDON – 78 Mount Street, London, W. 1, England

Lummus
PETROLEUM REFINING PLANTS

Here's Why

32 ALUNDUM Grinding Wheels Are Showing Such Startling Results

When ordinary abrasives are crushed to size it results in many grains with flat sides. When such grains are bonded into a wheel it is often a flat side that is exposed in the surface instead of a useful cutting point.

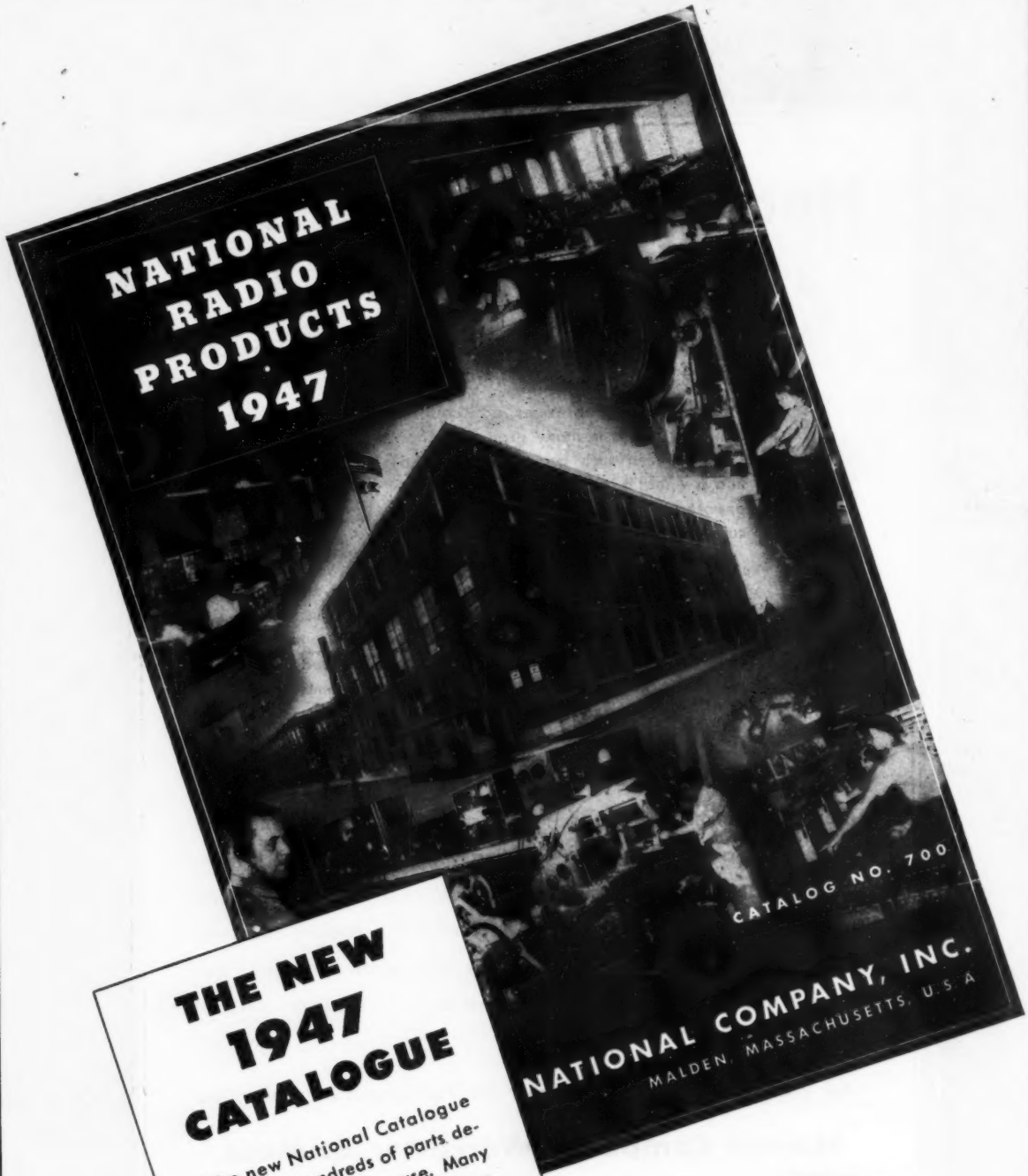
No crushing to size is necessary, however, with 32 ALUNDUM abrasive. The grains form as individual crystals—pointed *on all sides.* No matter how they are bonded into a wheel one or more cutting points are exposed. And they are longer-lasting cutting points because they are over 99% pure fused alumina.

The greater number of longer-lasting cutting points doing the work means that a 32 ALUNDUM grinding wheel removes stock more rapidly. Because grinding heat is spread over more points, and points that stay sharp longer, "32" wheels cut cooler. Because there are more points doing the work and points that don't dull quickly, 32 ALUNDUM wheels require fewer dressings and last longer.

Ask your Norton abrasive engineer for Vectograph Demonstration

Norton Company, Worcester 6, Mass.

NORTON ABRASIVES



THE NEW 1947 CATALOGUE

The new National Catalogue describes hundreds of parts designed for amateur use. Many items are new, some are unique. The old favorites are there, proved and improved over the years. New or old, the products in the new National Catalogue will improve your rig.

FOR INDUSTRY

Raw materials of the Cabot Companies meet many essential needs of industry.

The Retort Chemical Division of the Cabot Carbon Company is an example. In Florida, Retort takes the stumps of the timberlands and extracts pine tar, an essential in rubber compounds and a protective coating on cordage both ashore and on the nets of our fishing fleets.

The charcoal is used in the molds of the metallurgical industry.

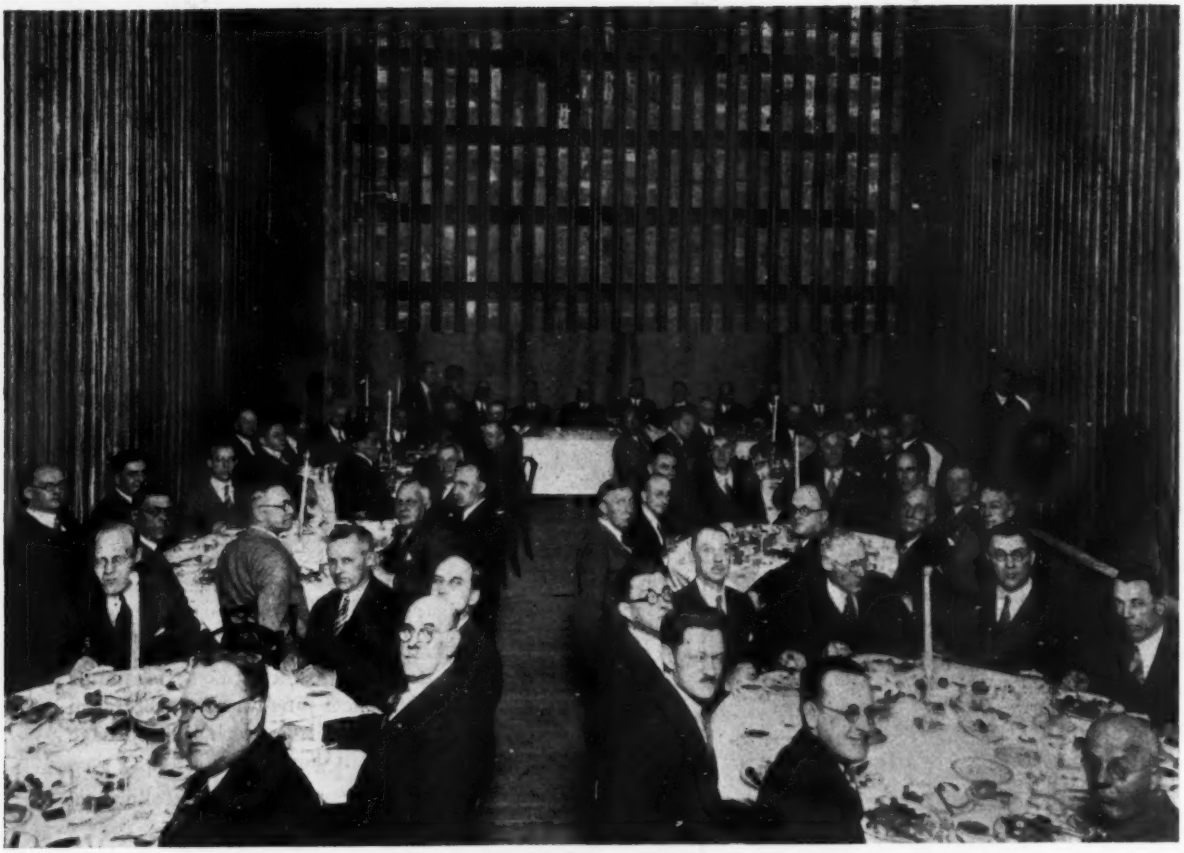
Cabot Companies utilize many other natural resources which might otherwise be wasted. In the oil fields, so-called "sour" natural gas, with a high sulphur content, first is stripped of natural gasoline to enrich the nation's motor fuel. Then the gas is burned in Cabot plants to manufacture carbon black for rubber, paints, varnishes, lacquers, inks and plastics.

Carbon Black
Natural Gas
Natural Gasoline
Pumping Equipment
Pine Tar
Charcoal
Carotene
Chlorophyl

CABOT CARBON CO.
TEXAS ELF CARBON CO.
GENERAL ATLAS CARBON CO.
CABOT SHOPS, INC.
VALLEY VITAMINS, INC.

CABOT

GODFREY L. CABOT, INC.
77 FRANKLIN STREET · BOSTON 10, MASS.



WORLD'S FIRST *million-pound boiler!*

At noon on December 2, 1929, ninety people lunched in a room which a few hours later had an average temperature of about 2500 deg. Fahr. Steel tubes formed the walls. 85 feet overhead were the dim outlines of huge drums. This improvised dining room was the furnace of the first boiler unit to produce a million pounds of steam per hour, and the luncheon celebrated the completion of three such units in the East River Station of the CONSOLIDATED EDISON COMPANY OF NEW YORK.

This unusual event marked a notable step forward in the economics of steam and power generation. A million-pound boiler costs substantially less to install and operate than two half-million pound units. Yet, until the East River installation — designed and built by Combustion Engineering — had demonstrated that a million-pound output from a single boiler was practical, there had been only one plant in the country with boilers capable of producing even half a million pounds. Now there are many installations for capacities above 500,000 pounds and, in the million-pound class, there are twelve units in service and four on order. Of these sixteen, eleven are Combustion Engineering designed.

The spectacular comparisons given below may help you to visualize a million-pound boiler, probably the biggest single production unit you'll find anywhere in industry. Combustion Engineering is proud of the engineering resources and manufacturing facilities that enabled it to build the first million-pound boiler — and a majority of those that followed it. And these same resources and facilities are available to you when you select *any* C-E Steam Generating Unit, small or large.

• A typical million-pound boiler is about ten stories high. • It's as wide as a four-lane highway. • The space in 5 six-room houses would just fill its furnace. • In one hour it burns 45 tons of coal, pulverized to the fineness of flour, with nearly 90 per cent efficiency. • The steam it produces would be sufficient to heat ten thousand average homes.

B-106

COMBUSTION ENGINEERING

200 Madison Avenue • New York 16, N. Y.

C-E installations cover all steam generating requirements from 30 horsepower stoker-fired boilers to the largest power station units.

EXPERIENCE ..at your Service

At American Bosch, engineering experience born of years of doing is at the service of Diesel users everywhere. Pooled with the Diesel Builders' own knowledge, this specialized fuel injection experience is at work today on the better, lighter, more efficient Diesels of the future.

Production skill and capacity which have kept pace with the industry's growth bring the engineers' work to reality. Widespread field service keeps the equipment operating efficiently.

Thus American Bosch experience serves from the conception of the engine to the product at work, which may serve to explain why a majority of America's Diesel Builders equip their engines with American Bosch Fuel Injection. AMERICAN BOSCH CORPORATION, Springfield 7, Mass.

AMERICAN BOSCH

AUTOMOTIVE AND AVIATION ELECTRICAL PRODUCTS

AVAILABLE in Universal, Plain and Vertical Types . . . easy to set up and maintain, they have a wide range of speeds and feeds . . . long service and low maintenance cost. (No. 2 Universal Light Type illustrated.) Complete details and specifications on request. Brown & Sharpe Mfg. Co., Providence 1, R. I.

BROWN & SHARPE

INTER-OFFICE MEMO

To: PLANT ENGINEER
Subject: PLANT RENOVATIONS

Secure services of experienced construction company with reputation for quality—responsibility—and low cost.

From: PLANT MANAGER

HORN BROTHERS
Incorporated
Building Construction
23 MINER STREET · BOSTON, MASS.

G. ARTHUR HORN, *Treas.*
Spec. Student '37

A. B. ELLENWOOD, JR. '34

THE TABULAR VIEW

Resplendent Trio. — SIR EDWARD V. APPLETON, Secretary of the Department of Scientific and Industrial Research in England, emphasizes (page 211) the benefits which may be expected from the close co-operation of the triumvirate of science, industry, and government. Representing virtually the complete text of the first Arthur Dehon Little Memorial Lecture delivered at Walker Memorial on November 19, 1946, "Science, Industry, and Government" acquaints us with the co-operative research carried on by the industrial research associations in England. Sir Edward's message has further significance, however, not alone because of the important place which scientific research occupies in our highly industrialized civilization; it is significant as an expression of international good will between scientists in all parts of the world. Sir Edward's distinguished career is chronicled on page 165 of the January, 1947, issue of The Review.

Research Lubricant. — Firm believer in, and active fighter for, the American way of life, ROBERT E. WILSON, '16, chairman of the board of Standard Oil Company of Indiana, Life Member of the M.I.T. Corporation, and 1943 Perkin medalist of the American Chemical Society, sets forth (page 217) convincing arguments for conducting industrial research in an atmosphere unhampered by restrictions. Dr. Wilson advances cogent reasons for believing that well-trained man power, freedom of opportunity, and the incentive of natural rewards for achievement are the factors most likely to insure continuance of the brilliant performance of science in promoting this nation's welfare. After postponing publication until Dr. Wilson was able to present it as an address at the Princeton Bicentennial Conference, The Review is happy to bring to its readers "Incentives for Research."

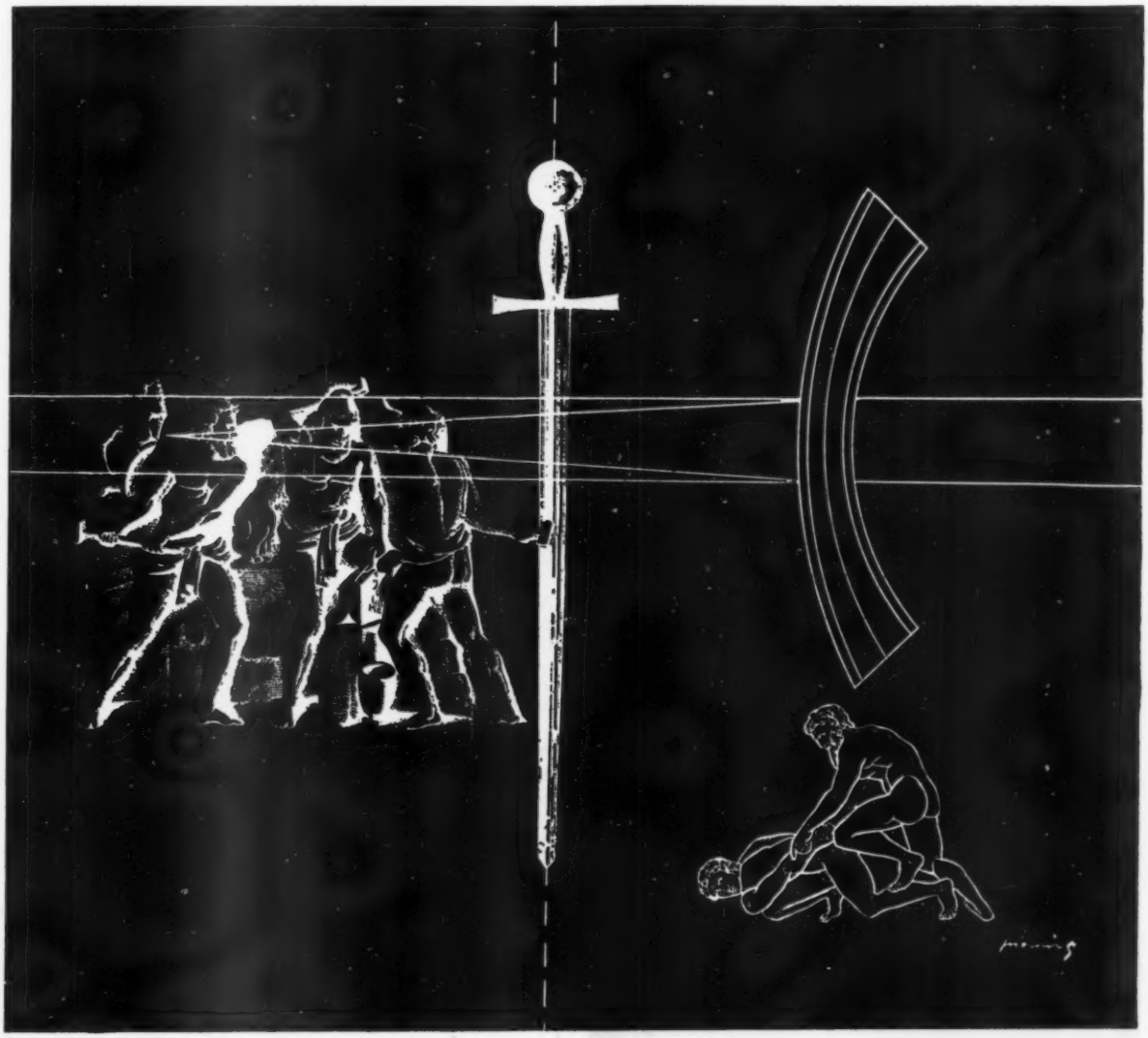
Diversify to Progress. — Looking askance at systems of regimentation, and even those customs and trends tending to produce uniformity in humans, PROFESSOR HENRY B. PHILLIPS, head of the Department of Mathematics, takes up the cudgels for individualism (page 220) in "Diversity and Progress," originally given as his presidential address at the M.I.T. Chapter of Sigma Xi. As a confirmed optimist, Professor Phillips expects local diversity to provide that leadership needed for future progress. After graduation from Erskine College in 1900, Professor Phillips received his degree of doctor of philosophy from Johns Hopkins University in 1905. He has been a member of the Department of Mathematics since 1907, its head since 1935, and is well known as author of several textbooks and mathematical papers.

Proposal. — After graduation from the Baltimore Polytechnic Institute in 1935, RICHARD A. NOVAK received a degree from the Institute in 1939 as a graduate of Course XV. During 1939–1940, he was teaching fellow at St. John's College in Annapolis, and since 1940 has been in the Aircraft Gas Turbine Engineering Division of the General Electric Company at Lynn, Mass. His interest in writing and in cultural aspects of education are reflected (page 221) in "Humanities in an Engineering School."

ONE CAME BACK

One of the legends surrounding the making of Damascus sword blades is that the smiths developed a delayed quench consisting of thrusting the heated blade into the body of a slave. This gave the required properties, but it was prodigal of manpower, and inconvenient besides. The smith usually had to leave town to do his heat treating in quiet.

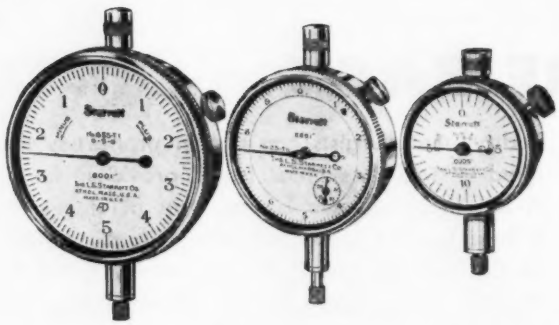
Today, metallurgists can obtain properties they need in steel by simpler, less improvident means. A little molybdenum is one way of doing this. It is a proved means of obtaining the hardenability that assures good performance in service. Practical working data on molybdenum steels are available from Climax upon request.



MOLYBDIC OXIDE—BRIQUETTED OR CANNED • FERROMOLYBDENUM • "CALCIUM MOLYBDATE"
CLIMAX FURNISHES AUTHORITATIVE ENGINEERING DATA ON MOLYBDENUM APPLICATIONS.

Climax Molybdenum Company
500 Fifth Avenue, New York City

MOLY



STARRETT DIAL INDICATORS

For any type, size, range, or style of graduation, see new Starrett Dial Indicator Catalog "L". Write for your copy.

Buy Through Your Distributor

THE L. S. STARRETT CO.
Athol, Massachusetts, U. S. A.
WORLD'S GREATEST TOOLMAKERS

STARRETT
PRECISION TOOLS • DIAL INDICATORS • STEEL TAPES • GROUND FLAT STOCK
HACKSAWS • BAND SAWS FOR CUTTING METAL, WOOD, PLASTICS

PRECISION—THAT'S THE REASON

Precision in production—that's the reason Diefendorf Gears can be depended upon for superior performance and longer life. From drawing board to finished product—Diefendorf Gears are precision engineered all the way.

Every Diefendorf Gear is engineered for its particular job.

Diefendorf Gear Corp.
D. W. Diefendorf '30, *President*
Syracuse 1, New York

diefendorf
★★★★★ GEARS

MAIL RETURNS

Objection to "Minority Report"

FROM ROBERT E. WILSON, '16:

While I am a believer in free speech even when I don't like it, I do not like to see The Technology Review print, without comment or challenge, a statement such as that on page 62 of the November, 1946, issue, where Tenney Davis comments: "Under such circumstances the use of the atomic bomb was like kicking a man who was down, slapping a prisoner already shackled, a needless display of bravado." I believe President Compton's analysis of this matter in the current *Atlantic Monthly* is a complete answer to this viewpoint, and should certainly be given prominence in your next issue.
Chicago 80, Ill.

Quotation

FROM FRANK EGNER:

Thanks ever so much for sending me the November, 1946, issue of The Technology Review containing the article which deals with the philosophies of libraries by John E. Burchard'23. This is a most searching study of the pressing library problem and I am mighty glad to have it. I want to keep it around for constant reference and quotation. It seems to me this is the best summary of the situation I have ever seen.
President, Funk and Wagnalls Company
New York 10, N. Y.

Bazooka Precursor

FROM MARTIN MANN, '41:

Willy Ley, certainly an authority on rockets (he was a prominent early member of the German Society for Space Travel, which later, absorbed into the Wehrmacht, produced the V-2), presented a very interesting historical analysis of their development in the December, 1946, issue of The Review. It is unfortunate that he neglected to mention that one belligerent in World War I *did* recognize the potentialities of rockets, i.e., the United States.

The Ordnance Department tested, quite successfully, the precursor of the present bazooka. Unfortunately for rocket research, the date was November 10, 1918, one day before the Armistice, and the project was dropped.

This weapon was invented by the late Dr. Robert H. Goddard, the Clark University physics professor who laid the foundations for modern rocket engineering. It remained for Dr. Goddard's assistant, Dr. C. N. Hickman, now of the Bell Telephone Laboratories, to pick up this work in World War II and direct development of the weapons listed at the end of Mr. Ley's article.
New York 10, N. Y.

Speed with Economy

We are now working on our 22nd contract for
AIR REDUCTION COMPANY
whom we have had the pleasure of serving since 1938

W. J. BARNEY CORPORATION
101 PARK AVENUE, NEW YORK
INDUSTRIAL CONSTRUCTION
Alfred T. Glassett '20, Vice President

FOR SOUNDLY ENGINEERED EXTRUDED PLASTIC SECTIONS

ASK Sandee

INDUSTRY everywhere has learned to *depend* upon Sandee Extruded Plastics. For here, only plastic materials of the finest quality are used. These, together with far advanced extrusion techniques and our experienced application engineering are continuing to expand uses of sound Industrial Extruded Plastics.

Sandee offers valuable aid in..1. Selecting the *correct* plastic material, 2. Developing the most efficient design for appearance, strength and economy, 3. Applying a degree of plastic extrusion "know-how" unsurpassed in the history of the industry! Sandee successfully extrudes large heavy sections as well as rods, tubes and smaller sections. Among the materials offered are, Polystyrene, Plexene, Vinyls, Ethyl Cellulose, Cellulose Acetate Butyrate, High Acetyl, Cellulose Acetate, Styraloy, and the Acrylics.

If a soundly engineered Extruded Plastic section is involved, by all means get the benefit of Sandee research, experience, and exclusive, greatly enlarged production facilities. Write today for complete information.

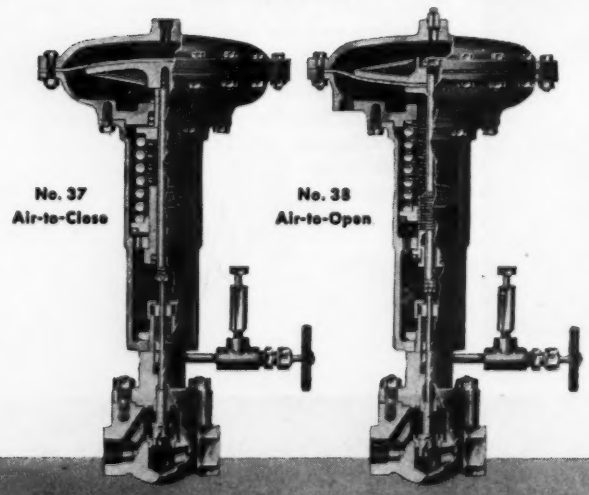
SALES REPRESENTATIVES IN 19 PRINCIPAL CITIES

Sandee Manufacturing Company

EXTRUDED PLASTICS AND SPECIAL TOOLS

The Interchangeable Plug and Seat Ring in Masoneilan Percentage Piston Control Valves Gives You

5 VALVES IN ONE



Because the trim size of Masoneilan Percentage Piston Valves is interchangeable, you can easily change any valve from one size to another by merely replacing the plug and seat ring. Since trim sizes are available in ¾", ½", ⅜", ¼", and ⅛", it means that you get 5 valves in one by simple conversion of the trim.

The flow range of orifice sizes of from ¾ to 1/16 inch represents a relative capacity ratio of 36 to 1. The capacities of the Percentage Piston Valves have been selected and spaced for the primary purpose of covering the desired range of flow with the minimum number of trim sizes.

In addition to interchangeable trim, these control valves give you the excellent flow characteristics of larger size valves even down to the ¼" size. The orifice diameter has been held to a minimum to reduce the errosive effect of high velocity fluids. Forged steel globe type body provides unusually large capacity.

Investigate Masoneilan Percentage Piston Control Valves. Catalog 301 gives complete information on construction, characteristics, selection and other important data. Write for your copy.

MASONEILAN

MASON-NEILAN REGULATOR COMPANY

1190 Adams Street, Boston 24, Mass., U. S. A.

New York · Buffalo · Chicago · St. Louis · Philadelphia · Houston · Pittsburgh · Cleveland · Tulsa
Atlanta · Los Angeles · San Francisco · Mason Regulator Company of Canada, Ltd., Montreal and Toronto

"Without laboratories men of science are soldiers without arms"—LOUIS PASTEUR

Why some things get better all the time

THE SPAN OF LIFE is increasing. Within the last half century the average length of life of a new born infant has increased over 30%. And many more people over 40 can now expect to live well into their seventies.

Among the reasons for this progress, along with notable advancements made by the medical profession, are the improvements in medicinals and medical equipment that help guard life.

Synthetic organic chemicals now are used in the production of a host of pharmaceuticals, including penicillin and the sulfa drugs, which have accomplished wonders in the fight against germs. They also are used in repellents to defeat disease-carrying insects. Out of research with gases has come oxygen therapy, an aid to recovery in numerous illnesses. Research with metals and alloys has produced the gleaming, easy-to-clean stainless steel used in modern hospital and medical equipment.

In safeguarding life—just as in transportation and communications—much of man's progress is traceable to *better materials.*

Producing better materials for the use of industry and the benefit of mankind is the work of UNION CARBIDE.

Basic knowledge and persistent research are required, particularly in the fields of science and engineering. Working with extremes of heat and cold—frequently as high as 6000° or as low as 300° below zero, Fahrenheit—and with vacuums and great pressures, Units of UCC now separate or combine nearly one-half of the many elements of the earth.

UNION CARBIDE
AND CARBON CORPORATION

30 EAST 42ND STREET UCC NEW YORK 17, N. Y.

Products of Divisions and Units include

LINDE OXYGEN • PREST-O-LITE ACETYLENE • PYROFAX GAS • BAKELITE, KRENE, AND VINYLITE PLASTICS
ACHESON ELECTRODES • EVEREADY FLASHLIGHTS AND BATTERIES • NATIONAL CARBONS
PRESTONE AND TREK ANTI-FREEZES • ELECTROMET ALLOYS AND METALS • HAYNES STELLITE ALLOYS • SYNTHETIC ORGANIC CHEMICALS

Four words that build better tires

ANOTHER REASON FOR GOODYEAR LEADERSHIP

When it comes to voting for a product leader, the polls never close. Ballots are cast day in and day out by people buying the product that offers them the highest quality, the greatest satisfaction.

For 32 straight years, the decision of motorists everywhere has been the same — *that Goodyear Tires are the best tires made.*

Such leadership must be protected . . . for you don't stay *first* unless you're *best.* Keeping Goodyear Tires first is the personal responsibility of every man and woman in the vast Goodyear organization. That's why you see the four words —"Protect our good Name"— on the walls of Goodyear factories and offices the world over. They are a constant reminder of that great responsibility.

Zealous guarding of Goodyear's reputation pays off to the motoring public with superior tire performance on the road. Every Goodyear Tire must be a leader in value — in longer wear and greater safety. This is another reason why it's true today — as it has been for so many years —"More people ride on Goodyear Tires than on any other kind!"

A pioneer in rubber, Goodyear also works with metals, fabrics, chemicals, plastics and other materials . . . making all Goodyear products better today than they were yesterday, better tomorrow than they are today.

GOODYEAR

THE GREATEST NAME IN RUBBER

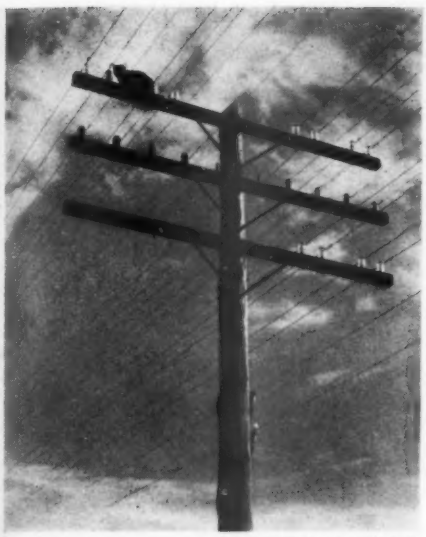


Photo by H. Armstrong Roberts

"I want to be alone!"

VOLUME 49 NUMBER 4

THE TECHNOLOGY REVIEW

TITLE REGISTERED U. S. PATENT OFFICE

EDITED

AT THE MASSACHUSETTS INSTITUTE OF TECHNOLOGY

CONTENTS for FEBRUARY, 1947

THE COVER — MASSACHUSETTS INSTITUTE OF TECHNOLOGY
From a photograph by Sargent Collier

SNOW ON "THE HILL" — FRONTISPIECE — 208

SCIENCE, INDUSTRY, AND GOVERNMENT — BY SIR EDWARD V. APPLETON — 211
Organization of Research for the Common Good in England

INCENTIVES FOR RESEARCH — BY ROBERT E. WILSON — 217
Free Enterprise Maximizes the Benefits of Scientific Research

DIVERSITY AND PROGRESS — BY HENRY B. PHILLIPS — 220
Major Defect of Central Control Schemes is Failure to Provide Diversity

HUMANITIES IN AN ENGINEERING SCHOOL — BY RICHARD A. NOVAK — 221
A Proposal for a Scientific Approach to Nonscientific Topics

☆ ☆ ☆

THE TABULAR VIEW — 200
Contributors and Contributions

MAIL RETURNS — 202
Letters from Review Readers

THE TREND OF AFFAIRS — 209
News of Science and Engineering

THE INSTITUTE GAZETTE — 223
Relating to the Massachusetts Institute of Technology

Published monthly from November to July inclusive on the twenty-seventh of the month preceding the date of issue, at 50 cents a copy. Annual subscription, $3.50; Canadian and foreign subscription, $4.00. Published for the Alumni Association of the M.I.T.: Alfred P. Sloan, Jr., Honorary President; Harold Bugbee, President; H. E. Lobdell, Executive Vice-president; Alf K. Berle, C. George Dandrow, Vice-presidents; Charles E Locke, Secretary; Ralph T. Jope, Treasurer. Published at the Rumford Press, 10 Ferry Street, Concord, N. H. Editorial Office, Room 7-203, Massachusetts Institute of Technology, Cambridge 39, Mass. Entered as second-class mail matter at the post office at Concord, N. H. Copyright, 1947, by the Alumni Association of the Massachusetts Institute of Technology. Three weeks must be allowed to effect changes of address, for which both old and new addresses should be given.

Publisher • H. E. LOBDELL *Editor* • B. DUDLEY *Business Manager* • R. T. JOPE

Editorial Associates

PAUL COHEN, T. L. DAVIS, F. G. FASSETT, JR., J. R. KILLIAN, JR., WILLY LEY, P. M. MORSE, F. W. NORDSIEK, J. J. ROWLANDS, E. R. SCHWARZ, D. O. WOODBURY

Staff { *Editorial:* THEODORA KEITH, RUTH KING
Business: MADELINE R. MCCORMICK

Photo by Acme

Snow on "The Hill"

THE
TECHNOLOGY REVIEW

Vol. 49, No. 4 February, 1947

The Trend of Affairs

Avocados and Fresh Herring

BY sea the journey would have taken six weeks, and chances of illness or death would have been high. So the pedigreed calf was flown from Miami, Fla., to Bogotá, Colombia. More recently, a flock of more than 33,000 baby chicks were flown from Oakland, Calif., to Manila in the Philippines with a mortality that was reported lower than would be expected for chicks that stayed on the ground. There have been many other examples lately of situations in which the airplane, in spite of its high cost per ton mile, is the preferred and, in fact, the economic means of transport.

Yeast, a highly perishable commodity in the tropics, is being air shipped in 5,000-pound lots in South America and the Caribbean area. While the speed of plane transport is an obvious and powerful argument for its use in handling foods in the tropics, it also appears to have cooler pastures to exploit. Experimental flights of fresh fish fillets from Norway to France and Switzerland are being made, the fish arriving at the markets of Paris and Zurich on the same day that they leave Trondheim.

Decidedly less experimental is the movement by plane of about 1,000,000 pounds or one-fifth of Cuba's 1946 summer crop of avocados to the United States. Bananas have also been shipped north by air. A scarcity of shipping space on merchant vessels has no doubt accelerated the trend, but there appears to be a permanent market for high quality, tree-ripened fruit flown in from the tropics. Not only does the tree-ripened fruit have a better flavor (and perhaps greater nutritional value), but the elimination of any ripening costs and a reduction in spoilage offset to some degree the higher freight rates of the plane.

In some cases, terrain or other obstacles give air transport a virtual monopoly. A typical case is the flying in of mining equipment and supplies to isolated regions. A recent example is the air line which has been established between Reyes and La Paz, both in Bolivia, although the former town lies at an altitude of 1,400 feet and has been cut off for all practical trade purposes by the great peaks of the Cordillera from the capital city lying at an altitude of 13,430 feet. Now La Paz is getting fresh meat from Reyes in an hour and a half. Incidentally, the refrigeration equipment necessary to establish this practice on a permanent basis is being flown into Reyes.

Electronic Excerpts

IN the United States, some 1,000 broadcasting stations daily grind out grist for more than 50,000,000 receiving sets in the nation. Electrical manufacturers produce more than 100,000,000 electron tubes annually to keep these sets in suitable operation. But the task of producing electronic equipment requires good brains, and lots of them. The research laboratory of one large electrical manufacturing company includes 3,000 books, 2,000 pamphlets, and 3,500 bound volumes of periodicals, all relating to electronics.

Radio receivers are back on the market in sufficient number to meet the peak demands. Instead of reflecting the quality which was built into wartime sets, many of the receivers appear to be below prewar standards for such sets. But good equipment is available too, if you can afford it. One domestic radio set was advertised in the New York *Times* at $1,024.50. Foreign made, deluxe receivers, advertised in the same newspaper, bear prices of from $1,495 to $2,500. It is enticing to speculate on the high quality of program material which would be required to make such equipment a home necessity.

In contrast to the mechanical system proposed for several years by the Columbia Broadcasting System, an all-electronic system of color television has been announced by the Radio Corporation of America who add that commercial use of the new color system is at least five years in the future.

Of more immediate interest is the prediction that production of custom-built television receivers (complete

Photo by Vachon from Standard Oil Co. (N. J.)

with automatic record-changing phonograph and amplitude-modulated, and frequency-modulated, radio receivers) may be 100 sets per month during the early part of this year. Viewing screens, on which will be produced black and white images, will vary from 9 x 12 inches to 18 x 24 inches. Those who attend the midwinter meeting of the Alumni of Metropolitan Boston at Walker Memorial on February 8 will see such equipment in operation.

Horse-Radish and Histamine

THE annual hay fever season never fails to bring forth in the popular press an alleged new remedy for that widespread and aggravating form of allergy. Some years the suggested remedies have been as simple and unsophisticated as the sniffing of freshly grated horse-radish; but hay fever news stories last summer were complex and generally inconclusive, because they featured new drugs designed to relieve allergies through antihistamine effects, and therefore involved reporters in the histamine theory of allergy, which on the whole appeared to baffle them.

That histamine, the principal factor in this theory, is always present in all tissues of the human body is not surprising, because histamine is derived directly from the amino acid histidine, a protein constituent found in foods. The histamine theory holds that when sensitive persons ingest or inhale substances called "allergens" a flood of histamine is released within the body, producing symptoms varying all the way from the respiratory discomforts of hay fever to skin reactions, such as hives. From this postulate that allergens and histamine are both links in the chain of allergic reactions, it follows that such reactions should be preventable by severing the chain at either link. Sometimes the allergen may be excluded, as by avoiding the eating of an offending food, or by going to a region where an offending plant pollen is not found. Or "specific" desensitization may be attempted by repeated injections of small, but increasing, amounts of the guilty allergen, in the hope of establishing a tolerance for that substance.

To break the histamine link of the allergen-histamine sequence, "non-specific" desensitization has been essayed by administration of series of histamine injections. Also, the enzyme histaminase, which destroys histamine, has been used; histaminase occurs in high concentration in the kidneys, and desiccated hog kidney is a preparation administered orally for histaminase therapy. Finally, there are the new drugs thought to possess antihistamine activity, including those recently featured in the newspapers, benadryl, pyribenzamine, and anthallan.

Histamine was identified and its chemical nature established in 1909; its physiological functions have been explored steadily ever since. Those functions that have been attributed to histamine include effects upon circulation, such as contraction of certain major blood vessels and increased permeability of blood-vessel walls. Also concerned with the blood stream is a postulated effect of histamine upon white blood cells in local inflammation. With relation to the digestive tract, some research workers have concluded that histamine increases the quantity of digestive juices secreted in the stomach, and also increases the acidity of these gastric fluids. Most arresting of the functions attributed to histamine is a role in cutaneous pain, where histamine is thought to act as a chemical mediator, being released from skin tissue by painful physical stimuli, such as cutting or heat, to act as a chemical stimulus upon sensory nerve endings. Finally, there is the histamine theory of allergy, as outlined in this discussion. But this explanation of allergic reactions is nothing more than a theory, and the other biological functions attributed to histamine are not only widely scattered and unrelated, but also are the subject of considerable controversy among physiologists.

Science, Industry, and Government

England's Utilization of Research on a National Scale Is Topic of First Arthur Dehon Little Memorial Lecture

By Sir Edward V. Appleton

THE proper direction of scientific effort and the proper application of the results of such effort are, I believe, among the most important challenges of our time. It seems to be typical of any postwar period that fundamental matters come under fresh scrutiny and fearless examination, and it is surely a good thing that this should be so. Stimulated by the realization of the magnificent services rendered by scientists in support of the Allied forces during the war, science and its consequences have become a matter of interest to the ordinary citizen. It is no new thing to the thoughtful mind that science has practical and social consequences. What is new is that the general public is now sharply aware of them. As a prominent newspaper man recently expressed it to me, "Science is news, as never before."

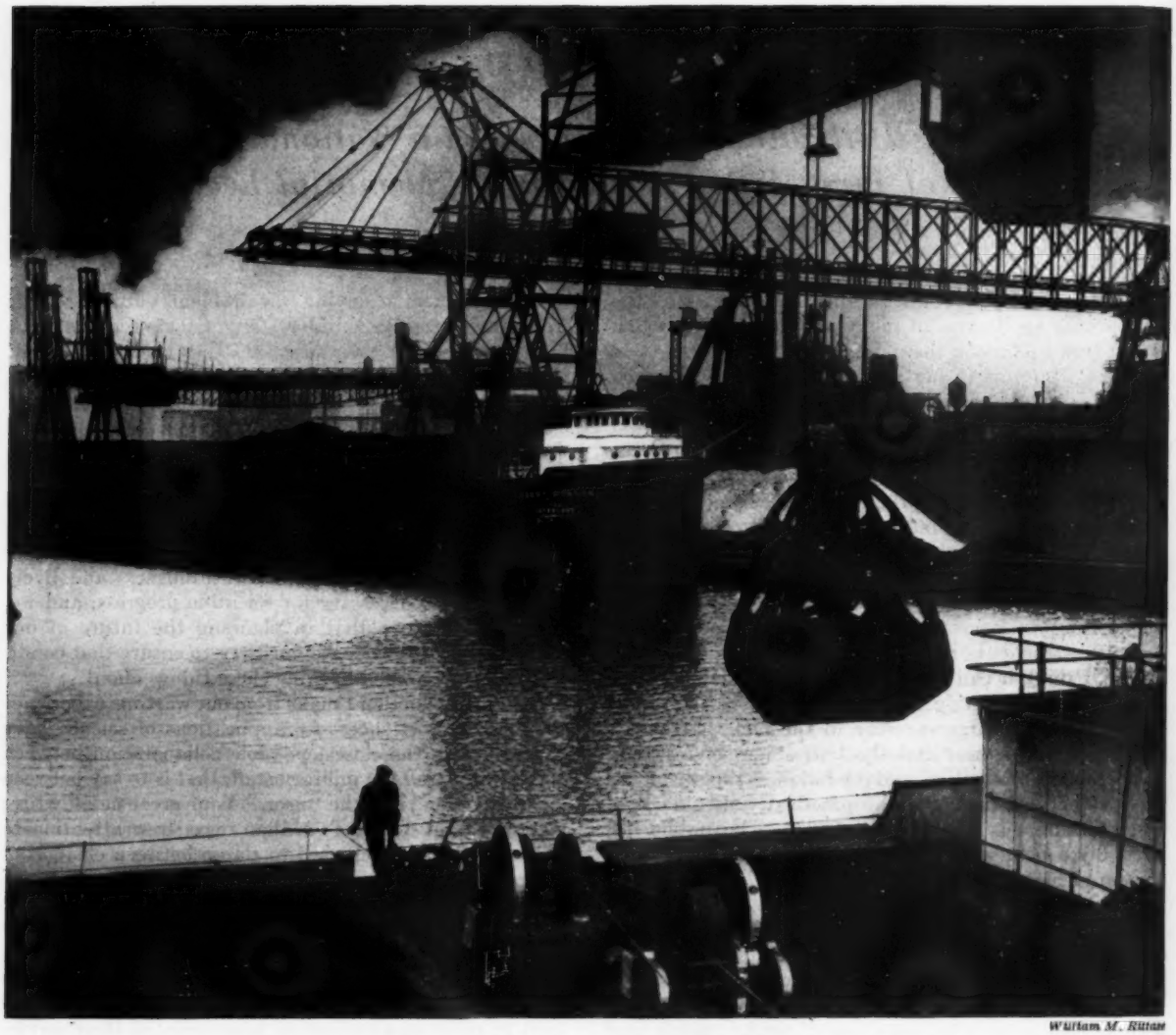
Now I think it can be said that this awakening to the importance of scientific work on the part of the public has been due in large measure to the fact that events move fast during war and the four stages of research, development, production, and use follow so rapidly on the heels of one another that the practical consequence of scientific effort is clear for all to see. The public has naturally concluded that if science can solve so many of the problems of wartime, it should play a similar role in solving the problems of peace. The problems that confront us now are, in an ultimate analysis, the provision of work, homes, food, health and safety — safety from aggression — for all; and these problems depend for their solution on the maintenance, in some degree, of the same kind of partnership between government, science, and industry which grew up during the war.

In approaching the problem of the future it may be helpful to cast a brief glance at the war years which have just passed, for I feel that we can draw certain lessons from that experience. In Britain the whole of our scientific man power was registered in 1939 and debarred from entering the Armed Forces without special permission. There was thus a reservoir of trained people for recruitment to the research establishments serving the Navy, Army, Air Force, and Civil Defense organizations. But even then the recruitment did not take place indiscriminately. The general policy adopted was not to recruit men from industrial research teams in industry. These teams were left practically intact. But in the case of university workers, who are generally more accustomed to work singly or in small groups, no such attempt was made; indeed an opposite policy was adopted. The result was that the research establishments of the services were strengthened by the addition of many brilliant minds from the universities, while the research teams in industry were ready to attack, as composite units, the problems allotted to them.

One of the most striking results of our wartime experience has been the brilliant success of our university research workers in solving war problems entirely remote from their peacetime interests. Various reasons have been advanced for their success. It has been pointed out that they had fresh minds. It has also been stated that, in approaching a difficult task, "they didn't know it couldn't be done." It has further been claimed that they had a better background of fundamental principles than the majority of those with whom they worked. I do not profess to be able to assign the result to any one of these causes. But what cannot be doubted is that university conditions certainly do, somehow, generally insure the maintenance of mental adventurousness and lively imagination so necessary for scientific progress; and we, in Britain, believe that in planning the future of our Scientific Civil Service we must try to ensure that conditions are encouraged to bring these things about.

Another deduction I make from our wartime experience is that the most successful applications of science have resulted from the closest possible collaboration between the scientist and the military staff, that is to say between the "provider" and the "user." Your great naval writer Rear Admiral Alfred T. Mahan once drew attention to the long period which used to elapse between changes of weapons and the consequent changes of tactics. He attributed this lag to "the inertia of a conservative class." Fortunately we can be satisfied that, in the war that has just ended, such gaps have not been unduly long. This has been due not only to the close collaboration between scientist and service man, but also to the fact that in many cases scientists have assisted their service colleagues in working out plans for the use of new weapons, and have been able to make post-mortem analysis of operational results whereby to check these plans. The field in which the scientist can usefully operate extends far beyond that of the laboratory.

My third comment on our wartime experience relates to subject matter. We have seen a mighty effort resulting in outstanding developments in weapons and instruments, culminating in the atomic bomb. By no means has all this effort been wasted, even if judged solely by its peacetime scientific interest and importance. But in this intensive drive many inviting scientific avenues have had to be merely noticed and passed by. When fundamental work has had to be done, as in the case of nuclear physics or in radio wave propagation, it has necessarily had to be objective in character and relevant to the major target. What I may call free fundamental work — free in the sense that its selection is dictated solely by man's curiosity — has been almost wholly in abeyance. We cannot recognize the return of peace in any better way than by changing all that. Our priorities must be revised. In many fields we have been living on our scientific capital which now stands urgently in need of replenishment. For this purpose the British Govern-



William M. Rittase

ment has set its own priorities, for the time being, as regards the release of scientific staff from government service in the following order: (1) universities and fundamental research; (2) civil science, government and industrial; (3) defense science. This is a complete reversal of the priorities which obtained in wartime.

Civil Science

In turning now to the future we note that, as in most countries, scientific research in Britain is, in the main, carried out by three types of organizations which differ somewhat in motives and objectives. These three organizations are universities, governmental agencies, and industrial research laboratories.

Universities and like institutions carry out what I shall call free fundamental research. If I may use the graphic expression of Dr. Vannevar Bush, '16, such educational institutions may be said to extend the endless frontiers of knowledge. This type of research, the result of intellectual curiosity and the love of truth for its own sake, is carried out without regard to any immediate or future useful application.

Government establishments carry out what may be called objective fundamental research and also applied research. By objective fundamental research is meant research designed to give insight and understanding rather than any special immediate practical result. It is called objective because it is relevant to some field of practical importance.

Industrial research laboratories carry out mainly applied research. In enlightened firms, a certain amount of objective fundamental research is also accomplished.

There is no sharp differentiation between the three groups of free fundamental, objective fundamental, and applied, research. However, I do find these divisions a more convenient classification than the older division into "pure" and "applied" research which always had, to my mind, the suggestion of snobbishness about it.

University Science

It is a remarkable fact that scientific research in the universities is of relatively modern growth. Scientific research, as we know it today, began in the Seventeenth Century when the experimental method replaced the method of *ex-cathedra* statement or argument by which, since the Middle Ages, man had endeavored to find truth. The scientific method of inquiring by observation, theory, and experiment has often been attributed to

William M. Rittase

Francis Bacon, though my own view is that Dr. William Gilbert, the physician of Queen Elizabeth and Fellow of my own College, St. John's at Cambridge, has a stronger claim to be counted its author. But the teaching of the experimental method did not form part of the university curriculum in the Seventeenth and Eighteenth Centuries, and laboratories did not form part of university equipment. Early in the Nineteenth Century, however, teaching laboratories for science were instituted and research became a spare-time activity of professors and lecturers. From small beginnings this has developed until it is now an accepted part of university tradition that teachers of scientific knowledge should also advance that knowledge. Moreover, although carried out in a spirit of pure inquiry, this free fundamental research has shown a surprising capacity for being useful.

Then we also look to our universities not only to make science but to train makers of science. We look to them for the supply of trained scientific workers who will later occupy positions in university, government, and industrial laboratories. We find that this training in research is best accomplished by a senior research worker acting as supervisor to a group of research students which should not be large.

We must never forget the outstanding importance of the exceptional man in this respect. Most of the really great advances in science have been accomplished by small teams of workers of this kind led by a man with ideas. As one concerned, to some extent, with the organization and support of science in Britain, I believe that a vital task is to see that these leaders — these men with ideas and inspiration — lack neither disciples, assistants, or equipment. When such needs have been satisfied the leaders should be left alone.

Government Science

Even apart from defense research, government in Great Britain conducts a great deal of research that perhaps would be regarded in the United States as being primarily the responsibility of industry or other bodies. Here we definitely enter the utilitarian field.

Though their object was, in the main, the satisfaction of their disinterested intellectual curiosity, the natural philosophers of the Seventeenth Century easily recognized that the results of their experiments could lead to important applications. Not only did they appreciate the importance of what Bacon called *experimenta lucifera*, experiments of light, which illuminate our knowledge of

the nature of things, but they also appreciated what he called *experimenta fructifera*, experiments of fruit, which yielded knowledge which could be applied, as Bacon pointed out, to extend the empire of man and to ameliorate the condition of man which he regarded as wretched. In his *New Atlantis* Bacon described what he calls Salomon's House, a kind of national research laboratory which had the object of arriving at "the knowledge of causes, the secret motions of things, and the enlarging of the bounds of human empire, to the effecting of all things possible." You will be interested to note that of the staff for this national laboratory he writes "We have three that try new experiments such as themselves think good. These we call Pioneers. . . . We have three that bend themselves, looking into the experiments of their fellows and cast about how to draw out of them things of use and practice for man's life and knowledge, as well as for works as for plain demonstration of causes, means of natural divinations and the easy and clear discovery of the virtues and parts of bodies. These we call Craftsmen or Benefactors. . . . Lastly we have three that raise the former discoveries by experiments into greater observations, axioms and aphorisms. These we call Interpreters of Nature."

Somewhat later, the scholarly Boyle, too, discoursed largely on the usefulness of the experimental natural philosophy, pointing out the usefulness of mechanical disciplines to natural philosophy and how the goods of mankind may be increased by the naturalist's insight into trades, and of doing by physical knowledge what is wont to require manual skill.

The close of the Eighteenth Century brought from America to Great Britain and Europe that singularly gifted secretary, general, and statesman, Benjamin Thomson, Count Rumford, who, while making several purely scientific discoveries of the highest importance, found practically the whole of the inspiration of his scientific work in his desire to use science to improve the living conditions of the common people. He was the first, I think, conscientiously and deliberately, to utilize science as a means of increasing the health, happiness, and comfort of his fellow man.

A. Devaney, Inc.

During the Nineteenth Century science was still studied primarily for its purely intellectual interest and very little was heard of the potentially useful applications of science. Still there were some who recognized this realm. A most interesting article in the *Fortnightly Review* in 1873 by Dr. George Gore, Fellow of the Royal Society, points out that scientific research is the only source of the new knowledge which is indispensable to national progress. His article contains the significant thought that without new knowledge the thoughts of men run in circles and intellectual and material progress ceases.

After calling attention to, what he calls, the deplorable lack of support given to fundamental scientific research, Gore proposed that there should be formed state laboratories for original research. In the course of his article he quotes a number of examples of what we would now call gaps in our fundamental knowledge and also a number of scientific problems whose solution he claims would be of great value to industry. Many of the problems he mentions have now been solved.

In his suggestion for state laboratories he is somewhat troubled about the need to insure that, with no set duties beyond instruction to carry out research, a man would not become idle. His ideas would raise a smile in these days for he writes: "Men who had previously exercised the degree of self-sacrifice necessary to make a number of long and difficult experimental researches, with only very limited pecuniary means, must necessarily be possessed of great enthusiasm in their calling, and would therefore be extremely unlikely persons to become idle by being supplied with a sufficiency only of means to carry on their labours. Further, such men might at present easily obtain a much larger income than they would receive in such a post, by abandoning research and devoting themselves to the various profitable engagements which are open to every man of scientific ability who is willing to devote himself to applied science. The practical work of research is much too arduous and difficult to permit such an office to become an object of desire to a place-seeking or idle person. But in order to exclude with certainty those who might hereafter devote themselves to research solely or primarily for the purpose of obtaining a well-paid appointment, and to ensure in all cases a reasonable continuance of industry, it would be necessary, that whilst the salaries paid should be sufficient to render the professors free from care, if expended with a reasonable degree of economy, they should not be so large as to conduce to idleness."

Research for the British Government

Very little notice seems to have been paid to these advocates of state assistance in the prosecution of research for the national benefit in Great Britain until the National Physical Laboratory was founded with Government assistance in 1900. It was set up largely as a result of the efforts of the late Lord Rayleigh who

realized earlier than most how the progress of modern industry depended to an ever increasing extent on accurate measurements and precise knowledge of the properties of materials.

It required the impact of the first World War, however, seriously to awaken the British Government to the necessity for State action in regard to scientific research and, as a result, in 1915 the Department of Scientific and Industrial Research was established as a separate Department of State, under the Lord President of the Council who is advised by an Advisory Council. The Department of Scientific and Industrial Research is not, of course, concerned with the whole field of science. Agricultural research and medical research are dealt with by sister organizations, also under the Lord President. There are, naturally, scientific experts in the ministries responsible for defense, trade, food, health, fuel, transport, and so on, so that there has been no attempt to confine scientific knowledge to one ministry alone since it has to be applied by many.

The major part of government civil research in the sphere of physical, chemical, and industrial interest is, however, centered in a group of 10 research organizations under the Department of Scientific and Industrial Research (D.S.I.R.) through which an attempt is made to provide a central scientific service for the executive departments of government and also to carry out research on matters of common interest to industry and to the community as a whole. That is the first function of the Department. The second is the encouragement of research by industry itself, particularly by fostering the formation of co-operative research associations. By means of grants, free fundamental research of timeliness and promise in the universities in Great Britain is promoted, and effort is expended to provide an adequate supply of trained research workers by means of maintenance allowances.

The Advisory Council advises the Lord President on all the Department's research activities and expenditure, which now is running at the rate of £3,000,000 per year. The Advisory Council is composed of men who have an expert knowledge of science or of industry and who serve in their purely personal capacity and not as representatives of any particular organizations to which they belong. When first formed, the Advisory Council was one of the first bodies composed of men outside government to advise on policy for implementation inside government. Individual members of the Advisory Council retire after five years' service.

In addition to the Advisory Council we have a research board or committee to advise on the work on each of our research organizations. Each board or committee is, again, composed of independent members who are chosen by the Lord President for their special knowledge and experience. Thus, by way of our various advisory bodies, our university and industrial scientists and our industrial leaders exercise a direct influence on the activities of the Department.

Governmental Research Establishments

The full list of the Department's stations includes: National Physical Laboratory, Building Research Station, Chemical Research Laboratory, Food Investigation Organization (dealing with the storage and preservation of food), Forest Products Research Laboratory, Fuel Research Station, Geological Survey, Pest Infestation of Stored Products, Road Research Laboratory, and Water Pollution Research Laboratory. The problems which these research laboratories attack — as may be surmised by the names given the laboratories — are, of course, current. Still, the basic overall need is one of considerably longer standing than might first be supposed.

William M. Rittase

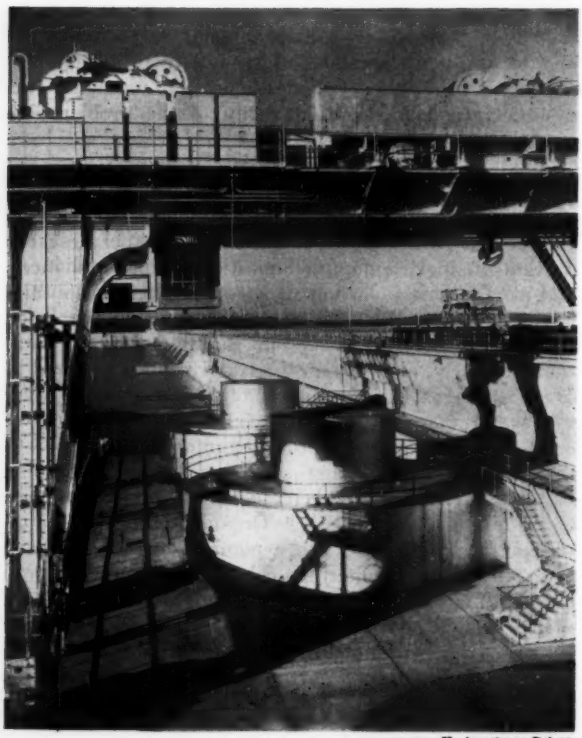
Earlier, reference was made to Count Rumford (who was born at Woburn, Massachusetts) as probably the first to apply the methods of science to problems connected with the primary domestic needs of mankind. It is a singular coincidence that many of the problems he investigated are precisely those for which we have thought it desirable to set up special laboratories. For example, his work on the economy of fuel, on the design of kitchen stoves, and on the reduction of smoke from chimneys is paralleled by the work of our Fuel Research Station on fuel economy, domestic heating appliances, and atmospheric pollution. His work on ventilation and the comfort conditions in rooms is similarly paralleled by projects undertaken by our Building Research Station. Similarly, his work on the tractive force required to draw carriages having wheels of various widths over roads of different types has connection with that of our Road Research Laboratory. Rumford also carried out research on food, paying attention to its nutritional value, its economy, and its efficient preparation; we also have a Food Research Organization. Finally, although there may be other comparisons which have escaped me, he invented his celebrated photometer and carried out researches on the lighting of rooms and the design of lighting fittings, activities which are continued today at the National Physical Laboratory. If we ever thought of adopting a patron for our Department, we should find it difficult to overlook Rumford's claim to that position!

Now I think it is important to note that our research stations, which seek to advance knowledge of community interest, are differentiated according to objectives. Therefore we have a Building Research Station, a Road Research Laboratory, a Fuel Research Laboratory, a Forest Products Research Laboratory, and so on. The staff of each of the stations is constituted as a balanced team of physicists, chemists, engineers, architects, biologists, and others according to the objective of the station. In addition, there are three stations organized subjectively, the National Physical Laboratory (by far the largest station of the Department), the Geological Survey, and the Chemical Research Laboratory. In addition to work on their own extensive program, these organizations naturally give specialist services to all the other stations in their own subjects.

Fuel Research Activities

Because a description of the work of all our stations could easily be wearisome, I shall select only one station as an example for brief comment, namely, the Fuel Research Station. This station was established shortly after World War I as a national research center for the study of fuel problems. Its work has included investigations on the carbonization of coal at high and low temperatures to improve the processes of manufacturing solid smokeless fuel, and gas and liquid fuels; on hydrogenation and other processes for the production of fuel oils from coal; on fundamental work dealing with the chemical constitution of coal itself. Work has also been carried out on the cleaning and storage of coal, and on the design of burners of gas and pulverized fuel.

A most important section of work at the present time is that of the National Coal Survey, which is conducted at nine laboratories of the various coal fields, with its headquarters at the Fuel Research Station. The purpose of the Survey is to determine the physical and chemical properties of our coals both as they occur in seams in the ground and as prepared for the market. On the basis of the data collected it is possible to indicate the most suitable uses of the different coals and to predict with considerable accuracy the probable properties of coal in seams that are as yet unworked.



H. Armstrong Roberts

The Coal Survey, in conjunction with the Geological Survey collaborates with the Coal Commission and the Ministry of Fuel and Power in assessing our national reserves of coal, which since 1942 have belonged to the nation. It will be seen that the data collected by the survey are essential in the planning of future mining operations if we are to use our not unlimited resources to the best advantage.

Recently the Fuel Research Station has intensified its research work in connection with domestic heating and atmospheric pollution. One of the major problems facing the country in the immediate postwar period, that of housing, has provided opportunities for great improvements in domestic heating. The Station has been called upon to assist the ministries concerned by testing appliances and advising on problems concerned with fuel for the home. Not least among these problems is that of reducing smoke emission.

In addition to work in its own field on the more efficient use of fuel, during the war the Fuel Research Station has dealt with such problems as the development of flame-thrower fuels and the design of gas-producers to enable road transport to operate on indigenous fuels. It has also developed a simple and effective method for preventing the emission of smoke by ships at sea, based on modification of the doors of marine boilers. This work should have important applications to land boilers in peacetime and unquestionably will help in reducing smoke pollution of the atmosphere.

As in the case of the Fuel Research Station, all our research stations left their peacetime problems largely in abeyance during the war and worked on matters of wartime importance. These problems arose either as specially urgent matters within their own respective fields or as entirely novel problems posed in the first instance by the Defense Research Departments. Our Road Research Laboratory, for example, keeping its staff and facilities intact, turned to the study of the physics of explosions. Its staff thereby became as expert on destroying concrete as they already were on making it!

Science and Government Functions

Now in considering the applications of science we must note the changing function of government. In Graham Wallas' famous phrase government "has come to be engaged not merely in preventing wrong things from being done, but in bringing it about that the right things shall be done." In discharging this most positive function we find that, to an increasing extent, science is being used as part basis for the formulation of government policy. A very interesting problem of organization therefore arises. We desire scientific knowledge to permeate the executive departments. How far, then, can a central scientific department serve these executive departments, and in what way should its service be supplemented by scientific staff and scientific work within the executive departments themselves? (*Continued on page 240*)

Incentives for Research

Only in an Environment in which Private Enterprise Reaps the Natural Reward for Advances which It Produces Can Full Benefits of Research Be Derived

By Robert E. Wilson

THE use of the term, engineering research, varies considerably in different quarters. In some companies and industries the term is used to include practically all applied research, as distinguished from fundamental scientific research. However, in many industries, and certainly in the chemical and petroleum industries, research in the field of applied chemistry or chemical engineering is not ordinarily considered to be engineering research. As a matter of fact, most large industrial research laboratories employ, roughly, equal numbers of chemists and chemical engineers, who work closely together, and even research on a pilot plant scale to develop information necessary for the design of large-scale equipment is not ordinarily referred to as engineering research. The latter term is more generally reserved for research in mechanical, electrical, metallurgical, and other fields of engineering which might be included under the general description of applied physics.

Broadly speaking, engineering research is more likely to be concerned with the solid state than is chemical research, and this, coupled with the complexities of engineering materials and structures, tends to increase theoretical and experimental difficulties.

When we come to consider incentives, there is little difference between the incentives for engineering research and those for any other kind of applied research, except that in most of its phases engineering research is expensive and not well adapted to university laboratories. It is also a relatively neglected field in which there is more need for rapid expansion than in the chemical and related fields in which research has had such spectacular growth during the past quarter century. Too much engineering design is still largely on an empirical basis. Adequate incentives for research are therefore particularly important to insure the prompt and adequate development of engineering research.

For the past few years there has been an understandable overemphasis on the spectacular achievements of science and engineering during the war. It is not necessary to devote consideration to such accomplishments, however, because the reader is already familiar with them, and there is no need to imply that the wartime achievements of research represent its principal claim to support. What I do wish to emphasize are the peacetime values of research and how to insure our having them. I should like to illustrate my thesis with some of the results of research in the industry in which I have worked for the past quarter century.

At the end of World War I it was felt that the petroleum industry had reached its peak and was about to go into a decline. Petroleum reserves were believed to be sufficient to last only about 15 years. Gasoline sold for about $0.30 a gallon and the elder La Follette predicted the imminence of gasoline costing $1.00 a gallon.

Now, at the end of another tremendously oil-consuming world war, the average service station price of gasoline is only $0.15½ per gallon (excluding taxes). Instead of using up our oil reserves in the predicted 15 years, we managed to find enough to keep us going at an accelerated rate for almost twice that long; and we have definitely proven reserves of petroleum four times as large as the total ultimate reserves estimated 28 years ago. In addition, the petroleum has been converted into far better products than were being made in 1918.

The dynamic factor which made these achievements possible has been improved technology which has resulted from research, and its application to every branch of the industry.

If this statement requires elaboration, we need but consider recent advances in methods of finding oil. In this field surface geology had about reached its capabilities by 1920. Then there came along, however, a whole group of new and highly sensitive physical instruments — the gravity meter, the magnetometer, and the seismograph — whose application changed completely the means of locating oil deposits. Operating on the surface of the earth, they permit rock formations to be mapped several miles deep in the earth, and have made possible the discovery of hundreds of new fields where there were no surface indications.

> *"Scientific discovery and its technical application make up a kind of self-propagating process, each new gain supplying the means or the impulse to the next one. A chain reaction may peter out because each element is too weak to excite an equal one to follow it, or because its scale is too small. Or it may grow indefinitely in speed and intensity, because its scale is sufficiently large and each element on the average is strong and quick enough to start off a greater successor. . . . Scientific discovery in the past has sometimes flared up locally and then died down again. . . . History can show many examples of regional civilizations which grew and flourished, and then somehow became unstable and disappeared. . . . There is a strong tendency in the human mind, particularly in England and America, to reflect complacently, 'Ah, yes, but those things never happen to us.' Perhaps the last few years may have taught some of us a lesson: they very nearly did happen to us."*
>
> Archibald V. Hill,
> *Secretary of the Royal Society*

In 1918 the physical limit of drilling was about 5,000 feet. New drilling methods, better steels, and many other inventions, as well as generally better engineering, have now made it possible to drill as deep as three miles, thus trebling the volume of earth from which oil can be recovered. Novel electrical logging devices, sent down a new well, use electrical methods or gamma rays to give a clear picture of the rock formation all the way down. They permit accurate contouring of structures and keep productive sands from being overlooked, as frequently occurred in the earlier days. By gas recycling and water flooding, aided by scientifically controlled production rates under proration, it is now possible to recover 60 to 70 per cent of the oil in many producing areas, as compared with 20 to 30 per cent in the earlier days. If 60 to 70 per cent recovery appears to represent low yield, it is well to recognize that we deal with rocks with a porosity about equal to that of a cement sidewalk, and at depths one to three miles below the surface. The recovery, through a single six-inch hole, of 70 per cent of the oil which underlies 20 acres is a real engineering achievement.

In the refining field, technology has made so many contributions that they cannot be recounted here. We are no longer mere refiners, purifying the products which nature supplies; rather are we large-scale chemical manufacturers, able to produce almost any desired yield or quality of motor fuel, as well as countless other products. Nevertheless, refinery costs per barrel are much lower than when we were mere refiners. Without the quality of gasoline and oil made possible by research, automobile engines would give less than half the power which is today obtainable from a given size of engine; our airplane engines would develop about one fourth their present power.

Extensive research has also shown us how to make gasoline and other petroleum products from natural gas at about present prices, and even how to make gasoline from coal and lignite at prices only five or six cents a gallon higher than current prices. If and when our petroleum reserves should become inadequate, such knowledge, resulting from research, will be invaluable.

Beginning of Research in Oil Industry

It would have been a tragedy, both for the public and for American oil refiners, if the petroleum industry had not engaged heavily in research. This thought causes us to stop and analyze how that research came to be done. Why did our industry, which 30 years ago employed less than 40 research workers (and usually excluded them from the refinery yard), expand this activity until today it employs several thousand full-time research workers and would like to hire as many more over the next few years?

I should like to be able to tell you that the oil industry's research was due to a broad, public-spirited interest in the welfare of our country. Frankness, however, compels me to let you in on a little secret, which brings me right to the heart of my subject. The real reason why our industry has spent hundreds of millions of dollars in research and development during the past quarter century is that we thought we could make a profit by so doing!

Although eventually we might have been smart enough to figure out for ourselves that research is profitable, our thinking was helped out by one fortunate event, if we can thus properly label the work of a pioneer.

About 1912 Dr. William M. Burton and his associates in the laboratory of the Standard Oil Company of Indiana invented the Burton process for cracking cheap heavy distillates to make gasoline. He showed not only how to control the conversion of large hydrocarbon molecules into smaller and more valuable molecules, but also how to do it at a considerable profit.

For some years the industry had been wondering how to meet the rapidly growing demand for gasoline with the limited quantity naturally occurring in crude oil. Dr. Burton's invention, which was widely licensed to other refiners, solved the problem. It conserved the country's petroleum supplies, it gave the customers better gasoline at a lower price, and it made millions of dollars for Dr. Burton's company. As an important by-product, it sold the petroleum industry on research. It pointed out, not only to technologists but also to management, that inventions have great cash value, and that to lag behind in technical developments was likely to be costly. The more progressive refining companies rapidly expanded their research, and this activity constantly grew as it proved its value in every branch of our industry.

The quarter century following 1918 saw more than a thirty-fold increase in the number of research workers in our industry. Today one independent petroleum research company, which spends two or three million dollars a year in its laboratories, is financed entirely by royalties on processes which it has developed and which it licenses mainly to the smaller refineries. While the larger oil companies are also quite willing to license their patents, royalty income is today a very small factor in the encouragement or financing of their research programs. In the highly competitive petroleum industry the oil companies are primarily interested in the direct effects of research on their own operations and in having something to trade with others, so as to be able to use the best process or combination of processes which anyone may develop.

Yes, the hope for profit, either as royalties or as earnings from operations is what has justified expenditures in the field of research. Those who are critical of the fact that several million dollars for patent royalties are annually collected or paid (and often one company is on the receiving end in one technical field, and on the paying end in another) may be reminded that the total scientific research and development expense of the oil industry is today around $40,000,000 per year, which is more than five times the current royalty payments. Furthermore, the saving to the American people in having gasoline at an average price (excluding tax) of $.015½, instead of the 1920 price of $0.29¾, has been around $4,200,000,000 in a peacetime year! Of course, not all these savings should be credited to research, but on the other hand, this figure does not include the tremendous additional savings due to better quality, nor the more important fact that, without the doubling of gasoline yield due to research, the prediction of a dollar per gallon for gasoline might well have come true.

Detriments to Future of Research

So much for the past. But what of the future of research? With such a past record you may wonder why further incentives for research are needed. The fact is, however, that in spite of this history of achievement, there are some serious clouds on the horizon which threaten the ability of research to continue its vital con-

tribution to the life of our nation. One such cloud is the fact that the simpler and easier problems have been solved. We are left with the more difficult ones. When I entered the petroleum industry in 1922 I was the second chemical engineer to be employed by my company, although it had about 25 chemists. All around the refinery were inviting problems which could be solved by a few weeks or months of intelligent application of engineering principles and which would save hundreds of thousands of dollars a year. Today every operation has undergone repeated scrutiny from chemists, engineers, and other scientists. It requires extensive study to make any major improvements. Also, in a highly research-minded industry the new improvements become obsolete much more rapidly than was once the case.

For these reasons the law of diminishing returns is beginning to apply to many fields of research. During the past quarter century our industry has passed through an evolution similar to that which occurred in the field of geographical exploration during the last century and a half. Daniel Boone with a rifle and a pack horse could add tremendously to public knowledge of new territory. Today it takes a Byrd expedition, a large, expensive, and well-organized group with much scientific equipment, to make any significant additions. In one respect, however, the analogy fails. Our geographical frontiers are necessarily shrinking as exploration proceeds. The frontiers of science, although becoming more difficult and expensive to penetrate, are ever expanding. Engineering research in particular offers many new and promising frontiers.

The Need for Trained Man Power

A second obstacle to research is the serious shortage of technical men which faces us, particularly during the next five years. As industrial operations become more complex, technically trained men are needed as operators or supervisors, and such jobs generally have priority over research. It will be impossible for our educational institutions to meet the demand for technical men during the next several years. This shortage stems back largely to the shortsighted policy pursued by the military authorities in drafting thousands of technical men for nontechnical jobs, and particularly in uprooting almost completely the young students who were part way through our technical schools. It seems strange that the nation which has profited most by the development of science and engineering was least enlightened in the utilization of technical and prospective technical men during the war. I have yet to find the individual within or without the military service who did not give at least lip service to the theory that technical men should be employed at scientific work, but the facts are that many thousands of technically trained men were put in the Army to do entirely nontechnical jobs, and that many promising young students were prevented from completing their technical education.

The third difficulty in expanding our research program is the accumulated deficiency in basic research. As was well pointed out in the very fine report made to the President by Dr. Vannevar Bush, '16, and his committee, we were too dependent before the war on European sources for much of our basic research. During the war we made tremendous advances in applying known principles of science, but we discovered very little that was basically

H. Armstrong Roberts

new or fundamental. This is one field where we have been drawing upon our reserves at an alarming rate.

A fourth threat to the future of research arises out of the attempt of a relatively small group to wreck our patent system. They have misrepresented the basic facts about patents and have filled the papers with discussions of a few unusual and nontypical, patent-control schemes, with which our antitrust laws are quite adequate to deal. They have even raised the old, worn-out specter of so-called suppressed patents. Both our previous and our present patent commissioners state they have been unable to discover any patents which have been suppressed. Facts and logic, however, seem of very little interest to detractors of the patent system.

Even emasculation of our patent system, however, would not today cause marked curtailment of the research programs of most large companies because they now realize that the main value of research to them lies in making new and better products, developing new processes, reducing operating costs, and so on. There would, however, be several very serious results of a substantial weakening of our patent system.

First of all, the smaller operating companies, independent inventors, and research and licensing companies would have little incentive to continue research. To them, income from the sale or licensing of patents is the only way in which they can reasonably expect to recover the extremely high cost of modern research. We would lose the diversity of approach and the independent viewpoint which have been of outstanding value to all industry. We must not overlook the fact that the telephone was invented by a teacher of the deaf, the telegraph by a professor of physics, celluloid, the first plastic, by a printer, and the Diesel engine by another professor.

The second unfortunate effect of emasculation of our patent system would be reversion to the dark ages of secret processes. Fundamentally the grant of a patent is not to reward a discovery, but to compensate an inventor for prompt and full disclosure (*Continued on page 232*)

Diversity and Progress

By Henry B. Phillips

IN comparing the present with the past we find few things have changed so radically as the idea of progress. As a result of a lifelong study of the matter J. B. Bury[1] of Cambridge University concluded that, until the last two centuries, the idea of unlimited advance had never existed anywhere. Yet, now, expectation that the future will surpass the present is almost universal. This is significant for it may imply recognition that perpetual progress is now possible for the first time. Thus it is interesting to consider what are the conditions favorable to progress and whether any of these exist to an extent that has not occurred before.

Consider first some of the characteristics of progress, assuming that, over the long periods with which we are concerned, progress is measured by the creation rather than the distribution of resources.

Progress results from the efforts of all the people. Thus it is a group accomplishment but one of a rather peculiar nature. In the usual activities of everyday life, the total accomplishment of a group of workers is the sum of the things done by its members. We are accustomed to accept this additivity of effects as a universal principle. For the advances which constitute progress it is not valid however. If a group of men engage in research and 10 of them make the same discovery, not 10 discoveries are made but only one. For work of this kind the total accomplishment of the group is not the sum of the things done by the individuals but the sum of the different things. The total accomplishment of the group, therefore, is greatest when the activities of its members exhibit greatest diversity.

The same conclusion follows when we consider that progress involves a continual advance into the unknown. At each step of such advance, features are encountered which are not logically dependent on anything previously known, and which consequently cannot be foreseen by any intelligence however great. The results are thus subject to chance and the total influence of chance increases as the interval under consideration is lengthened. Since the probability of success in any game of chance increases with the number of trials, it follows that progress is most rapid when the trials made have greatest diversity.

Thus, whether we consider progress as group accomplishment, or advance into the unknown, diversity is indicated as the optimum condition.

Failure to provide this diversity is a major defect in all schemes of central control. In any such scheme a single decision must be reached, and because of the influence of chance, any single decision relative to the future is probably wrong. This difficulty is just as serious in democracies as in other forms of government. As the term is now used, the central feature of democracy is majority rule. Unfortunately, there is only one majority. In matters where chance plays a predominant role, this means the majority is doomed to be nearly always wrong.

To this one might object that, despite its defects, majority rule is better than minority rule. That is undoubtedly true but it is not necessary to have either. In addition to majority rule and minority rule there are many other kinds of rule. In particular, there is the case of no rule at all, under which form greatest progress has been made.

Suppose, for example, you have the misfortune to have appendicitis. If you choose a good surgeon your chances of survival are almost 100 per cent. When I was a boy, however, I knew a number of people who had appendicitis, every one of whom died. What is responsible for this change from almost certain death to almost certain survival? No law on the subject has been passed by Congress or any of the state legislatures. Even the medical societies have probably done very little. Individual doctors and hospitals have merely improved their methods and others have followed the methods found to work best. Thus, under no rule at all, it has come to pass that people with appendicitis no longer have to die. Similarly in all lines, progress is most rapid when there is least rule because this is the condition under which the actions of people have maximum diversity.

Failure to provide this diversity is a defect not only in real states but in all the utopias created by human imagination. The authors of these imaginary states give to their creations such limited and static structures that if their utopias were established and left without interference it is doubtful if they could even survive. And certainly in a little while, through lack of progress, the inhabitants of these ideal states would merely work harder, have less, and die earlier than people in the rest of the world.

In some of these utopias neglect of diversity appears even to be deliberate. Thus, Plato in his *Republic* inquires what quality is most desirable for the citizens of his ideal state to have, and concludes that this quality is unity. It is not entirely clear what Plato meant by unity, but Aristotle, who knew Plato better than we ever can, seems to infer that Plato meant the citizens should be essentially alike. For in his great essay on politics, Aristotle quotes this theory and criticizes it. He says there can be too much unity, that a state does not consist of many people but of many kinds of people.

Cycles of Civilization

Of the many kinds of people the most important are those of superior ability, and the development of these is the greatest step in human progress. In historic times human ability has been subject to wide periodic variations. A most interesting study of these variations was made by W. M. F. Petrie,[2] the eminent English Egyptologist. Petrie divides the last 7,000 years of Mediterranean history into eight periods. Each period begins with an invasion by a foreign race. This is followed by an interval of gestation usually lasting from six to eight centuries. Then there is rapid development reaching its peak first in sculpture, and then, successively, in painting, language, mechanics, and finally in wealth. After a brief period of luxury, decay sets in and this (*Continued on page 226*)

[1] J. B. Bury, *The Idea of Progress*. (New York: Macmillan Company, 1920.)

[2] W. M. F. Petrie, *The Revolutions of Civilizations*. (New York: Harper and Brothers, 1922.)

Humanities in an Engineering School

The Teaching of Liberal Arts May Benefit as Much from Plato's Method of Dialogues as from Application of the Scientific Method

By Richard A. Novak

WITH increasing frequency, graduates of scientific schools are being called upon to pass judgment upon matters not strictly amenable to mathematical treatment and not easily subjectable to controlled laboratory conditions. More frequently they are being asked questions involving human relations, philosophy, economics, sociology, and especially politics. It is a natural presumption of the layman that one who is skillful and intelligent enough to deal successfully with the complex problems of science is one whose voice should be heeded in other matters.

It is unfortunately true, however, that rare is the scientist or engineer who can honestly claim to know more about the nonscientific problems confronting the world today than the average intelligent layman. At a time when his prestige is high, and the need for an authoritative voice is great, he must either admit his ignorance or pretend knowledge. If he does the former, the world is left in the hands of the men who put it where it now is. If he pretends a knowledge which he does not have, and trades upon the name of scientist, he places himself in the same category as the primitive practitioner of black magic who danced about his patient in weird headdress.

There is nothing new, of course, in the suggestion that the way out of this dilemma should lie in the right application of scientific methodology. In the terminology to be used here, the words "liberal arts" could be substituted for "scientific methodology." For the present purposes, the liberal arts will be defined as those arts having to do with the proper and skillful manipulation of symbols. The methods of science are one example of this proper and skillful use. It is perhaps not too much to say that the physical sciences are pre-eminent today only because those who pursue them have been consciously, almost painfully, aware of themselves as manipulators of symbols.

Approach to Instruction in the Humanities

The thesis of this paper is that in its instruction in the humanities the scientific or engineering school would do well to make equally explicit the manipulation of symbols in nonscientific subjects. The interplay made possible by a comparison of the use of symbols in scientific and nonscientific fields should make this task easier.

To make clear what is being suggested, it would perhaps be best to adduce a simple example. Let a geometrical system of some sort be assumed. It can be described by a number of postulates and definitions and by the theorems which arise logically from them. Such a system, taken by itself and without reference to actuality, has what can be called a truth-value which is a function of its internal consistency. There is, in other words, a very real sense in which the geometry can be called true or false, even though it may have no relevance whatsoever to actuality. Let this type of truth or falsity be called the primary truth-value of the system.

If our geometrical system is applied to the measurement and description of some segment of actuality — for instance, a chair — and it is seen to describe the geometrical characteristics of the chair adequately, it may be said to be true in a different way from that described as primary truth. Let this type of truth or falsity be called the secondary truth-value of the system.

It may be well to point out here that the system is said to be representative of actuality, that is, to have a high secondary truth-value, when it adequately describes the measurements taken of actuality. The consideration of importance here is that, strictly speaking, a high secondary truth-value implies a high degree of correlation between system and measurements. It is unjustifiable to equate measurements of actuality with actuality.

The process of measurement really requires that actuality be treated as though it were itself a symbol. We impute to some segment of actuality a meaning, dictated by the system and by the limitations of instruments available, in much the same manner that we assume a word has meaning. Instead of having recourse to a dictionary to evaluate this meaning, however, we apply some unit-measuring stick, the instrument, and then define actuality in terms of the measuring stick. It has often been pointed out that measurement is a metaphorical process, differing little from the use of metaphors by the poet or philosopher. To say that a table is five feet long is to say that there is a relation between the unit-foot length and the table length which is the same as a relation between one and five. William E. Johnson in *Logic* * has shown that more commonplace metaphors have the same form. Thus, when an Australian speaks of England as the mother country, he is really saying that there is a relation between England and Australia which is the same as the relation between mother and child. The formal similarity between the two cases is easily apparent.

There is nothing new or startling in what has been said above. If it achieves any mark of distinction at all, it probably can be said to arise from an oversimplification and, possibly as a consequence, distortion of a complex process. Since, however, our purpose is simplification, this may not be entirely bad.

Primary and Secondary Truth-Values

Having stated in outline form the structure of a geometrical system and having indicated the criteria for

* *Logic* by William E. Johnson. (New York City: The Macmillan Company. Part I, $6.25; Part II, $4.50; Part III, $4.25.)

statements of truth or falsity of that system, let us turn our attention to something nonscientific.

Let us assume there are two opponents who are having a political argument. It will not require too much imagination to put the opponents into violent opposition. Not infrequently such arguments

Facts

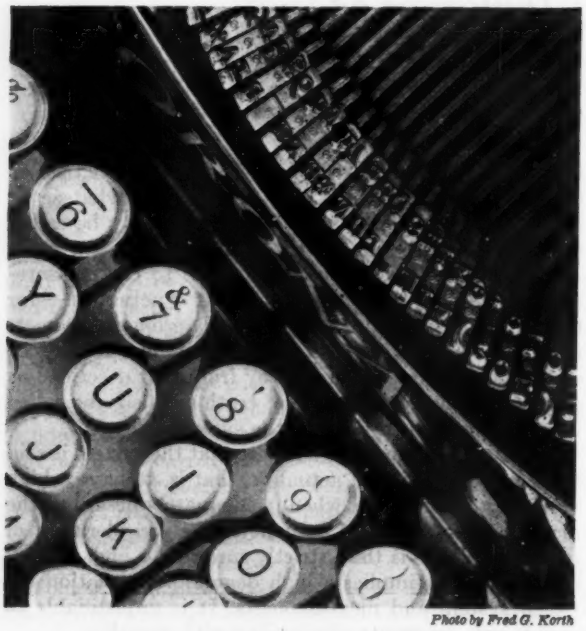


Photo by Fred C. Korth

The methods of science are one example of the proper . . and . . . skillful manipulation of different sets of symbols.

end in blows; between nations they may be a contributing factor to wars.

Without specifying the particular issue of the argument, it is proposed to take our geometrical system as a formal analogue and attempt to determine at what points either opponent may be judged right or wrong. Assume that opponent *A* has made a statement; it can be any statement. We may consider this statement as a theorem in some system analogous to the geometrical system. Inasmuch as it is a theorem, it presupposes some postulates and some definitions.

We can investigate *A*'s statement solely in the light of the postulates and definitions upon which it is based. If it is logically consistent, we may say that it has primary truth and to that extent may be right. We may, however, find that *A* is not aware of the axioms which generate his statement. If, by judicious questions, we are able to bring them to his attention, he may confirm or repudiate them. Note should be taken that there is little difference between such critical investigation of postulates by persistent questioning and what the psychoanalyst tries to do in his treatment of an unbalanced person.

Implicit in the above statement is the assumption that human beings are not, in general, illogical. Usually, what is called an unreasonable or illogical opinion is one the axiomatic grounds of which are unclarified. Sometimes it is more convenient for a man to be called unreasonable than it is for him to reveal, to himself or to others, the postulates which would justify his logic.

The point of importance here, however, is that an opinion can be considered as a theorem of a system which may be investigated for its systematic or primary truth-value without any consideration being given to its secondary truth-value. Such an investigation imposes upon the investigator a disciplined approach to the uses and misuses of symbols. Its ultimate value lies in the cleansing effect which the revealing of postulates will have.

Once a statement has been investigated in its systematic context, it is possible to subject it to similar scrutiny to determine its secondary truth-value. The units of measurement should arise naturally from, and be consistent with, the postulates and definitions of the system. In effect, the units of measurement will impose their meaning upon actuality as questions, and actuality will answer with a "yes" or "no." It remains only to decide whether the questions are trivial or significant.

The suggestion is not being made here that arguments, especially political ones, are very often carried through to completion along the above lines, nor is it even being suggested that they should. It is believed to be important, however, that parties to a discussion understand to what they are party. To hold opinions on a political, or any other issue, is to take upon oneself the intellectual responsibility to discover and evaluate one's axioms. Only when this has been done can any rational estimate be made of the opinion. Only when this has been done is one justified in convictions firmly held, for then only are they held with a knowledge of what they involve and imply.

The Humanities in Engineering Schools

It would be well to return now to the original problem and discuss what bearing all this may have on the teaching of the humanities in an engineering school. It is being maintained here that what any course in the humanities should teach is not politics, not philosophy, not economics, but rather the liberal arts. It is to be remembered that the liberal arts were defined above as the arts having to do with the proper and skillful use of symbols. (*Concluded on page 230*)

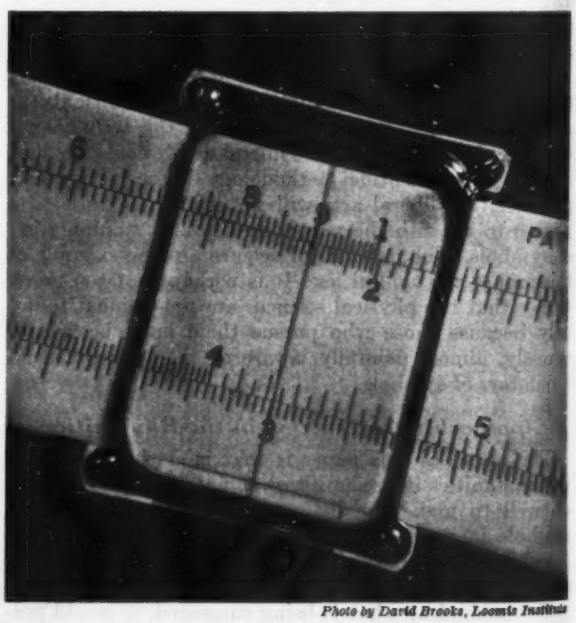


Photo by David Brooks, Loomis Institute

Figures

THE INSTITUTE GAZETTE

PREPARED IN COLLABORATION WITH THE TECHNOLOGY NEWS SERVICE

Institute Finances

IN presenting the Treasurer's report on M.I.T. finances for the fiscal year 1946 a gradual tapering off, rather than the expected sharp decline, in the volume of transactions for the year following the end of the war is reported by Horace S. Ford. Total volume for the 1946 fiscal year was $30,000,000; two-thirds that of the previous year, but more than that for 1944. Endowment and other funds showed a total book value of $46,000,000 compared with $43,000,000 for the previous year.

Largely because of the increased number of returning students, the educational and administrative operations totalled $4,000,000 as against $3,470,000 for the year 1945. Expenses exceeded income by $109,000 and the all-time cumulative operating deficit, at the time of the report, stood at $7,100.

Two items on the asset side of the balance sheet should be especially noted. Advances for current operations, $3,700,000, are $250,000 more than for the previous year, occasioned largely by long delayed payments of student tuition fees of veterans, sponsored by the Veterans' Administration along with other government contracts. The $4,000,000 of accounts receivable is almost $1,000,000 less than for the previous year.

For the year past, new loans from the Technology Loan Fund were but $16,000 against repayments of $122,000 which brings the total of notes outstanding against student borrowers to $422,000 out of the $1,800,000 total of the Fund. Repayment to maturities of more than 98 per cent is being maintained.

From the financial point of view, the student housing project at Westgate needs at least 15 years of continued occupancy to be reasonably well amortized. Income on this $500,000 commitment is not likely to exceed two per cent. Building 22 of the Radiation Laboratory has been purchased for student occupancy and its reconversion to barracks-type housing has cost $153,000 including equipment, which is not likely to be recovered.

The third or F.P.H.A. housing project, in which families are now moving, consists of the two-story Navy barracks which have been erected immediately west of Westgate and is known as Westgate West. The initial cost of providing the site, grading, filling, and bringing in the services supplied to these buildings will require an expenditure of Institute funds of approximately $130,000. The government allows a return of $15.00 per family per year of occupancy. If this project should last for five years and be completely rented to 180 families during this time, the return would be but $13,500, leaving an anticipated deficit of $110,000 to $115,000, not including the cost of demolishing the buildings.

The three emergency housing projects which the Institute now operates may, therefore, be expected to represent a loss of between $250,000 and $275,000, a rather substantial contribution from the Institute to the pressing housing shortage of the community.

Of Past and Future

WITH an attendance of 99 members and guests, the 253d dinner meeting of the Alumni Council was held in Pritchett Hall of Walker Memorial on November 25, 1946. Harold Bugbee, '20, President, called the meeting to order at 7:05 P.M. and introduced Professor George Owen, '94, newly elected Council representative for the Class of 1894. Professor Avery A. Ashdown, '24, introduced his guests, Robert J. Hansen and Edward Cole, graduate students at the Institute.

In presenting his report, Alumni Secretary Charles E Locke, '96, announced that a midwinter meeting of the Alumni of Metropolitan Boston has been scheduled to be held on the evening of February 8 in Walker Memorial. President Karl T. Compton will introduce Dr. Everett M. Baker, Dean of Students. Dr. Vladimir K. Zworykin, Associate Director, RCA Laboratories, will explain and demonstrate the operation of a complete television system in a program lasting an hour and a half.

Saturday, June 14, 1947, has been selected for Alumni Day when M.I.T. Alumni will return to Boston to renew old acquaintance and attend the Stein-on-the-Table Banquet. The Executive Committee nominated the following committee chairmen who were elected by the Alumni Council: *Banquet*, William W. Garth, Jr., '36; *Exhibits*, Herbert L. Beckwith, '26; *Ladies' Program*,

Official Navy Photo

For his service as wartime director of the Anti-Submarine Warfare Research Group in the Atlantic, Professor Philip M. Morse was recently awarded the Medal of Merit by Rear Admiral Monroe Kelly, U.S.N., Commandant of the Third Naval District. Professor Morse, well known to Review readers as one of its editorial associates, is on leave of absence to serve as director of the Brookhaven National Laboratory, devoted to pure research in atomic sciences.

Mrs. William H. McAdams; *Luncheon*, John B. Wilbur, '26; *Publicity*, Ralph T. Jope, '28; *Registration*, Wolcott A. Hokanson, staff; *Symposium*, Donald Whiston, '32; *Transportation and Hotel Accommodations*, Emmons J. Whitcomb, '11; *Ways and Means*, Delbert L. Rhind, staff. Parke D. Appel, '22, Alumni Day Chairman for 1947, presented plans for observance on June 14, announced "Advances in the Air" as the theme for the forenoon symposium, and reported that the Hotel Statler would be the scene of the annual banquet.

In the absence of George Warren Smith, '26, chairman of the special committee on the Boston Luncheon Club, the Alumni Secretary reported that daily luncheon meetings were being held from 12:00 to 1:30 P.M. at Thompson's Spa on Washington Street in Boston. Council members were urged to attend these meetings when possible.

H. B. Richmond, '14, presented the report of the Committee on Resolutions for the late Henry D. Jackson, '95.

At 8:00 P.M. the Council had the good fortune to listen to a 10-minute inaugural address by President Karl T. Compton, which opened the Beaver Network. As recorded on page 166 of the January, 1947, issue of The Review, this activity provides a student-operated, carrier-current broadcast system for dormitory residents.

Vice-president James R. Killian, Jr., '26, gave an account of his recent visit to nine local clubs throughout the country. With the return to more nearly normal peacetime conditions, Dr. Killian found clear evidence of renewed interest in local clubs. He found alumni interest high in the M.I.T. program of humanities and in extracurricular activities.

John W. Leonard, Jr., '47, coxswain of the M.I.T. crew, spoke briefly on crew activities, and especially the trip to the regatta in the State of Washington last June. He was followed by Ralph T. Jope, '28, who gave the story of M.I.T. collegiate crew activities from early days down to the recent Washington regatta. Finally, James B. McMillin, crew coach, gave a historical account of the history of rowing, with some sidelights on the activities of the crew. There followed movies of the crew on the Charles River and also at the June regatta.

Hope *for the Dinghy Fleet*

A NEW experimental dinghy for the M.I.T. Nautical Association was recently christened at the Sailing Pavilion when Miss Hope Wiswall named the new boat *Hope* as she broke a bottle of Narragansett Bay water over the bow of the little craft. Miss Wiswall, a Radcliffe student, is the niece of Paul M. Wiswall, '09, donor of the new dinghy.

The new boat is a trial model, designed by George Owen, '94, retired Professor of Naval Architecture, who drew up the original plans for the present Technology fleet. The present fleet is beginning to show its age after 10 years of almost constant use, and a new fleet is indicated sometime in the next few years. The new model is similar to the original boats in dimensions and lines, except that a canoe stern replaces the transom type, and the boats have been given more stability amidships. The canoe-type stern gives greater rigidity of construction, particularly should molded plywood or one of the new plastic processes be used in the construction of the new fleet. The *Hope* has proved very satisfactory in trials.

Sailing at Technology has proved increasingly popular since it was introduced in the spring of 1936. The membership of the Nautical Association reached a new high this past year with 1,057 members representing approximately one-fifth of the Institute population. In addition to an increased intramural program, the sailing team captured all three major dinghy championships, the McMillan Trophy (large yachts), the Morss Bowl (dinghies), and the Star Class Intercollegiate Trophy. In addition, Roger Willcox, '42, won the National 110-championship in the Morss, one of the Technology fleet. M.I.T. sailors captured 19 first places and four of the second places in the total of 23 regattas during the past year. Technology skippers, Charles M. Hunt, Jr., '47, Daniel W. Greenbaum, '47, John Marvin, '49, Leigh A. Brite, '46, and Alfred A. LaFountain, '47, were the first five men in the traditional 10 best skippers selected from the 33 colleges which now form the Intercollegiate Yacht Racing Association.

Miss Hope Wiswall christens the new experimental dinghy Hope *as Commodore Stephen B. King, '47, and Professor Erwin H. Schell, '12, look on. Instead of the traditional champagne, water from the Narragansett Bay was broken over the bow in reminiscence of the region where Paul M. Wiswall, '09, donor of the dinghy, first learned to sail. The new boat was designed by Professor George Owen, '94, who also designed the M.I.T. dinghy fleet which has been in constant use during the last decade.*

M.I.T. Photo

Economics and Engineering

THE Visiting Committee on the Department of Economics and Social Science * met on March 15, 1946, at the Racquet and Tennis Club in New York. George A. Sloan, the chairman, entertained the group at lunch, after which discussion centered upon a new undergraduate course in Economics and Engineering. As explained by the representatives of the staff present at the meeting, such a course would be designed for those planning to become staff executives in the economic, personnel, statistical, or other departments of a business, governmental, or labor organization. It will also serve those who will go on to graduate work in economics in preparation for teaching. In the past, such persons have come into their profession from the liberal arts colleges. The Institute's new course offers the engineering approach. The student will be equipped to use the methodology of exact science in the analysis of economic problems. Being grounded in engineering, he will be prepared to evaluate the impact of technology upon our economic life. The country needs economists with an engineering background.

The subjects in Economics and Engineering have been selected with a view to achieving three main objectives: to impart some knowledge of human behavior; to show how industry is organized and operated; and to give some conception of the broader aspects of economic, political, and social problems. Students have the choice of two options: Human Relations and Industrial Economics.

The Human Relations option emphasizes the first of these objectives. It is planned to help the student to be effective in his relations with superiors, associates, and subordinates. It therefore includes such subjects as advanced psychology, labor relations, the management of people. The Industrial Economics option emphasizes the second of the above objectives — to provide an understanding of economic institutions and industrial organizations. It includes such subjects as industrial economics, finance, analysis of price and production. In both options professional electives afford an opportunity to pursue further study in related fields.

Although the course is set up especially for those with tastes and aptitudes for economic analysis and its application in industry and government, the engineering content is substantial. The dual character of the program is evident from the fact that, while it meets the educational requirements for "junior economist" under existing civil service regulations, at the same time, it is adequate to qualify graduates as certified engineers. In the third and fourth years a student may choose one of three groups of subjects selected from the offerings of the Mechanical, Chemical, and Electrical Engineering Departments.

There was some discussion of the provision making students choose one of these three groups of subjects rather than permitting them to select subjects from several different branches of engineering. The Committee came to the conclusion that the group system is preferable. It insures that the engineering study will be carried beyond the beginning stage, thus making the program more interesting and of greater educational value than if students elect a scattering of elementary subjects. As to the nonengineering content, the Committee questioned the omission of accounting. Although it was pointed out that accounting could be chosen as an elective, there was a strong feeling that students in both options should be required to take this subject. Statistics and production were also mentioned as basic requirements.

Several members emphasized the desirability of carefully selecting the students to be admitted to the course.

The plan as a whole was unanimously approved. There was no feeling that by going into economic education M.I.T. was stepping outside its traditional role as a scientific and engineering institution. In fact, this new course was regarded as a valuable addition to the educational opportunities which the Institute has to offer.

* Members of the Committee for 1945–1946 were: George A. Sloan, Chairman, Franklin W. Hobbs, '89, William J. Barrett, '16, Raymond H. Blanchard, '17, Edward P. Brooks, '17, Oscar S. Cox, '27, and Carlton Richmond. Also attending were: James R. Killian, Jr., '26, Vice-president, Robert G. Caldwell, Dean of Humanities, Douglass V. Brown, and Ralph E. Freeman of the Department.

On December 2, 1946, Secretary of War, Robert P. Patterson, awarded the Medal for Merit to Professor Julius A. Stratton, '23, in recognition of his outstanding service in initiating, and successfully administering, wartime programs for the development and effective tactical use of radar and related scientific devices. Dr. Stratton, who was expert consultant, Office of the Secretary of War, during the war has become director of the Institute's Electronics Research Laboratory.

Photo by U. S. Army Signal Corps

DIVERSITY AND PROGRESS

(*Continued from page 220*)

decay continues until the old race becomes "too weak to imitate anything when a fresh race comes in, and utilizes the old stock to graft on both in blood and culture. As soon as the mixture is well started it grows on the old soil, and produces a new wave of civilization."[3]

This is the pattern repeated during each cycle of Mediterranean civilization. Since sculpture, painting, and other developments came about in the same order in each cycle it was possible, by study of these, to determine the phase of civilization reached at each instant. In some cases, larger sections of a people migrated to distant lands and remained long out of contact with the home country. In such cases Petrie found that the civilization of these migrant people remained in phase with that of the home country and did not acquire the phase of the new. From this he concluded that the phase of civilization at each instant is in the blood of the people and is not influenced by environment.

In explanation of these facts Petrie suggested that each cycle of civilization was due to the mixing of two races. When two races occupy the same country and there is free intermarriage, there comes a time when every possible combination of ancestry has been made, when each individual in the population is, in most cases, not only descended from both races but is a descendant of each one of the original settlers. Petrie calls this condition complete mixing. Assuming that the population never exceeds that of large modern countries, the number of generations required for complete mixing depends on the initial population. Petrie made rough calculations but exact analysis shows that, if the initial population is not more than 1,000,000, complete mixing occurs in 24 generations. If the initial population is 10,000,000, this condition will be established in 27 generations, and even with an initial population of 100,000,000 complete mixing is accomplished in about 31 generations. Assuming the generations to average 30 years, seven to ten centuries of mixture of two races thus "ensures that, in any ordinary sized country, the full maximum number of different ancestors are blended and every strain of one race is crossed with every strain of the other."[4] This is the period of greatest biological diversity and Petrie's analysis shows it initiates the period of greatest ability.

When any group of living things is long subjected to a fixed environment, forms unsuited to that environment are gradually eliminated, and finally there remain only those better fitted to survive. This screening process is called natural selection. Since this process consists merely in the elimination of forms unsuited to the particular environment, the surviving forms are left more and more alike and so less and less capable of adaptation to a different environment. Thus species long subjected to fixed conditions lose capacity to change, and when conditions do change may be unable to survive.

In the human species this reduction to common type is greatly aided by social influences. In childhood play, in school, and in all the activities of life, whose who think and act in the conventional way find life easier and, in the end, leave more progeny to continue the normal trend.

In a settled community the diversity due to racial mixing ultimately reaches its peak, whereas the leveling influence of environment never ceases. The latter influence thus ultimately dominates, diversity diminishes, and progress comes to an end.

Now, when progress ceases, civilization does not stand still, but, as Henry George so strongly emphasized, always turns back.[5] The reason for this is that the major part of the things which distinguish a high from a low state of civilization results from the efforts of a small portion of the people, and in the leveling process these are the people most severely reduced. At the present time, for example, only a small percentage of the people are able to design and build electric power equipment. In a reduction to common type most of these would be eliminated. With the disappearance of electric power our standard of living would drop to a level that would appear only a little better than that of ancient Greece and Rome.

But however long this leveling process continues, it never becomes complete. The nation continues to have able men, the number per million of population merely declining. Just as in a cold gas there are particles with as great velocities as in a hot gas, so in a backward people it is not the maximum ability that is low but the nature of the distribution that is changed. Under the leveling influence of custom and environment, there is a shifting away from genius toward mediocrity.

Ahead Lies Wealth—and Decline

In Petrie's diagram the period which began with the fall of Rome is still continuing. For this period we have passed the peak in sculpture, painting, and language, and are in the great era of mechanics which has now broadened out to be science. Ahead lies only the phase of maximum wealth, and, if the pattern of the last 7,000 years still persists, beyond that is the great decline. But may not conditions have changed so radically as to make that pattern forever obsolete?

In the matter of racial mixing, conditions certainly have completely changed. In former times there was very little travel. In settled countries nearly all the people spent their lives within a few miles of their places of birth, and their descendants remained in the same neighborhood for centuries. Impelled by lack of food, or desire of conquest, hordes of people occasionally moved into neighboring countries and these invasions sometimes started new periods of civilization. Now invasion has been replaced by immigration, and this process is continuous. A new period of civilization is thus starting all the time.

Consider the United States, for example. Our present culture has been transplanted mainly from western Europe and belongs to a late phase of the period which dates from the fall of Rome. Our population is, however, a complex one containing large elements from all the important countries of the world. Few of these people have been in the United States for 10 generations and most of them for less than five. Thus, mixing is not the thousandth part complete and will not become complete for four or five centuries. When the civilization based upon this mixture begins to flower, the old civilization transplanted from Europe will not yet have reached its end. In the meantime, during each century, there will have come into the United States greater multitudes than those which in the Fifth Century swept down over Rome.

(*Concluded on page 228*)

[3] *Loc. cit.*, p. 114.

[4] *Loc. cit.*, p. 129.

[5] Henry George, *Progress and Poverty*, Book X, Chap 7. (New York: Doubleday, Page and Company, 1915.)

REVERE PHOSPHOR BRONZES
OFFER MANY ADVANTAGES

1—Plunger guide
2—Thermostat spring
3—Internal lock washers
4—Contact springs
5—External lock washers
6—Operating lever
7—Cap with integral springs in side
8—Retaining spring
9—Countersunk external lock washer
10—Pressure spring for capacitor
11—Five-contact spring
12—Contact spring for radio part
13—Pressure spring and terminal
14—Involute spring
15—Contact point for solenoid
16—Contact springs
—made of Phosphor Bronze strip supplied by Revere

STRENGTH — Resilience — Fatigue Resistance — Corrosion Resistance—Low Coefficient of Friction—Easy Workability—are outstanding advantages of Revere Phosphor Bronzes, now available in several different alloys.

In many cases it is the ability of Phosphor Bronze to resist repeated reversals of stress that is its most valuable property. Hence its wide employment for springs, diaphragms, bellows and similar parts. In addition, its corrosion resistance in combination with high tensile properties render it invaluable in chemical, sewage disposal, refrigeration, mining, electrical and similar applications. In the form of welding rod, Phosphor Bronze has many advantages in the welding of copper, brass, steel, iron and the repair of worn or broken machine parts. Revere suggests you investigate the advantages of Revere Phosphor Bronzes in your plant or product.

REVERE

COPPER AND BRASS INCORPORATED

Founded by Paul Revere in 1801

230 Park Avenue, New York 17, New York

Mills: Baltimore, Md.; Chicago, Ill.; Detroit, Mich.; New Bedford, Mass.; Rome, N. Y.—Sales Offices in Principal Cities, Distributors Everywhere.

•

Listen to *Exploring the Unknown* on the Mutual Network every Sunday evening, 9 to 9:30 p.m., EST.

DIVERSITY AND PROGRESS

(*Concluded from page 226*)

Even if immigration were prohibited, the result would be but little changed. A sufficient complex of races is already within our borders. For example, if there were no further immigration, the Japanese already here make it practically certain that 1,000 years from now every United States citizen will have Japanese blood.

Under the ferment of continual mixing we may thus expect continual expansion. The serious question is whether this will be held in check by universal custom in the one world we are in the process of making. Through radio communication, moving pictures, and the printed page a closer contact is being established between all parts of the world than ever existed before. These and government services must have a form that appeals to the majority. Under these common influences there is a tendency to make all the people alike and leave the world occupied by a mediocre race which lacks the diversity essential to progress. If this did happen, it might indeed mark the end of civilization, for when the present wave had run its course there would be no savage race to fuse with the decrepit stock and start a new era.

But there is strong reason to think this will not happen. When former civilizations decayed and died, it was in small nations where conditions were far more uniform than can ever exist in the entire world. Differences in geography and climate are sufficient to maintain differences in people. In the United States, for example, certain characteristics distinguish North, South, East, and West. People who move from one section to another quickly acquire the characteristics of the new section, and rarely retain the old for as long as a generation.

Diversity, the Basis for Progress

Unless forced by central or collective action, geographical diversity may thus be expected to persist. In a small community forced action is easily possible. But as the size of the community increases it becomes more and more difficult to get specific regulations which can be enforced. Ultimately, a critical size is reached such that enforcement is impossible. Our difficulties with prohibition and the bootleggers, with price control and the black markets, indicate that the United States is approaching the critical size. The debates in the United Nations Organization suggest that the whole world exceeds that size.

We may expect that, whatever form of world sovereignty is established, local diversity will continue to supply the basis for progress. Countries in which things are done best will continue to have greatest strength and their methods will finally prevail.

Many would say this analysis is not pertinent since it takes no account of the new atomic developments; that reckless use of the forces thus introduced may set a period to civilization itself.

To people who have fixed ideas as to how the world shall be run, this atomic era does bring a shock, but for progress itself — that is a different matter. All history indicates that when attack is stronger than defense, progress is rapid. The reason, of course, is that the weakness inherent in wrong methods is more quickly exposed and these methods are swept away. For example, only a few years ago the United States government compelled its citizens to limit production. Now there is not enough of anything and half the world is faced with starvation. In a secure world, possibly we could permit limitation of production and merely depress the standard of living throughout the world, but that is much less likely when at any moment we may face the test of strength.

As to destroying civilization, I doubt whether people who make that suggestion realize what they are saying. Suppose, for example, in an attack with atomic bombs all the towns in the United States of more than 2,500 population were completely destroyed. This is greater destruction than any I have seen suggested. A town of 2,500 inhabitants is hardly more than a village. The material required for such an attack exceeds the foreseeable resources of any group of hostile nations. Nevertheless, let us assume every town of 2,500 inhabitants or more completely wiped out. At the end of that operation the United States would still have more inhabitants and greater resources than it had when I was born. Starting from that level, my generation raised this country to a height never attained by any other nation. If necessary, I am confident your generation would do that again.

Thus we have reason to believe conflicts between nations and ideologies can only check the rate of progress and not change its ultimate nature, that diversity of population already exists and whether we have peace or war will steadily increase, that conditions throughout the world differ too widely for any form of uniform regimentation, and that, under the diversity thus assured, progress in the sense of working less, having more, and living longer will be the future experience of the majority of mankind.

HAROLD J. RYAN, INC.

Air Conditioning

101 PARK AVENUE NEW YORK 17, N. Y.

Rogers Peet Company

MAKERS OF FINE CLOTHES for Young Men and Men Who Never Grow Old

Westminster Dog Show! Dogs of countless breeds the sportsman can admire or develop! Breeding and training a major medal winner is a real job—a job packed with dreams of the approach to perfection . . . At Rogers Peet the same basic idea—the approach to perfection—is always uppermost in the mind of our Master Designer — perfection in fabric, style, tailoring and fit—perfection in clothes for young men, and men who never grow old.

FIFTH AVENUE *at* 41st STREET, NEW YORK 17, N. Y.
THIRTEENTH ST. *at* BROADWAY, NEW YORK 3, N. Y.
WARREN STREET *at* BROADWAY, NEW YORK 7, N. Y.
TREMONT ST. *at* BROMFIELD ST., BOSTON 8, MASS.

The right thing in everything men and boys wear

HUMANITIES IN AN ENGINEERING SCHOOL

(*Concluded from page 222*)

In the terms we are using, a philosophical system has a structure very similar to that of a geometry. It is a collection of theorems or statements which derives its logical validity from the postulates and definitions upon which it is based. Whether or not one believes that philosophy has any relevance to actuality or has any practical use is really beside the point. A mathematician does not discard a non-Euclidean geometry because it has no application. He is interested in the primary truth-value of the system. Similarly, a philosopher, insofar as he acts like a philosopher, does not concern himself with the secondary truth-value of his structure. If he adds to it the injunction to believe, he does so as an individual human being, not as a philosopher.

Similarly, it is believed that economics would not suffer from the type of criticism suggested here. Criticism of this sort does come, of course, from the expert economist. For only to the extent that he is able to handle symbols skillfully and properly can he be called an expert. But such criticism and understanding do not come from a student who is being given a course in economics to round out his education.

It remains to indicate how, in an engineering school, the humanities are to be taught from this point of view. One answer was given a few thousand years ago in the Platonic dialogues. Socrates and the other participants of the dialogues discussed problems of precisely the type which have been the concern of this paper. They did it, figuratively speaking, around a table.

Why cannot the same procedure be followed in an engineering school? Why cannot a thoroughly adequate foundation be given to the nonscientific studies by carefully selected reading assignments and subsequent discussion in seminars? Such a procedure would seem to be especially suited to a school of science. The basic proficiency in handling symbols is, supposedly, being given in the regular scientific courses. All that is really needed is some means to reflect the light of this proficiency upon nonscientific subjects. What better means of reflection can there be than a seminar or organized reading?

The reading lists, of course, will be dictated by the subjects under consideration. It is perhaps well to stick as closely as possible to the so-called classics of any field. The reason for this is simple and does not arise from intellectual snobbishness. One of the reasons why a classic is able to maintain its high status lies in the richness of its symbolism. It is much like actuality in that respect. A given occurrence in the physical world is amenable to many interlocking meanings and references, depending upon the system in which one wishes to consider it. It is so with a classic. It endures because men can find in it many meanings. Such a characteristic is valuable for a seminar, the avowed purpose of which is the study of meaning.

To anyone who has read the books of Scott M. Buchanan and Mortimer J. Adler, much of what has been said above will have a familiar ring. The reader may be assured that this is not a coincidence.

LEWIS-SHEPARD

POWER JACKLIFT

Master of them all!

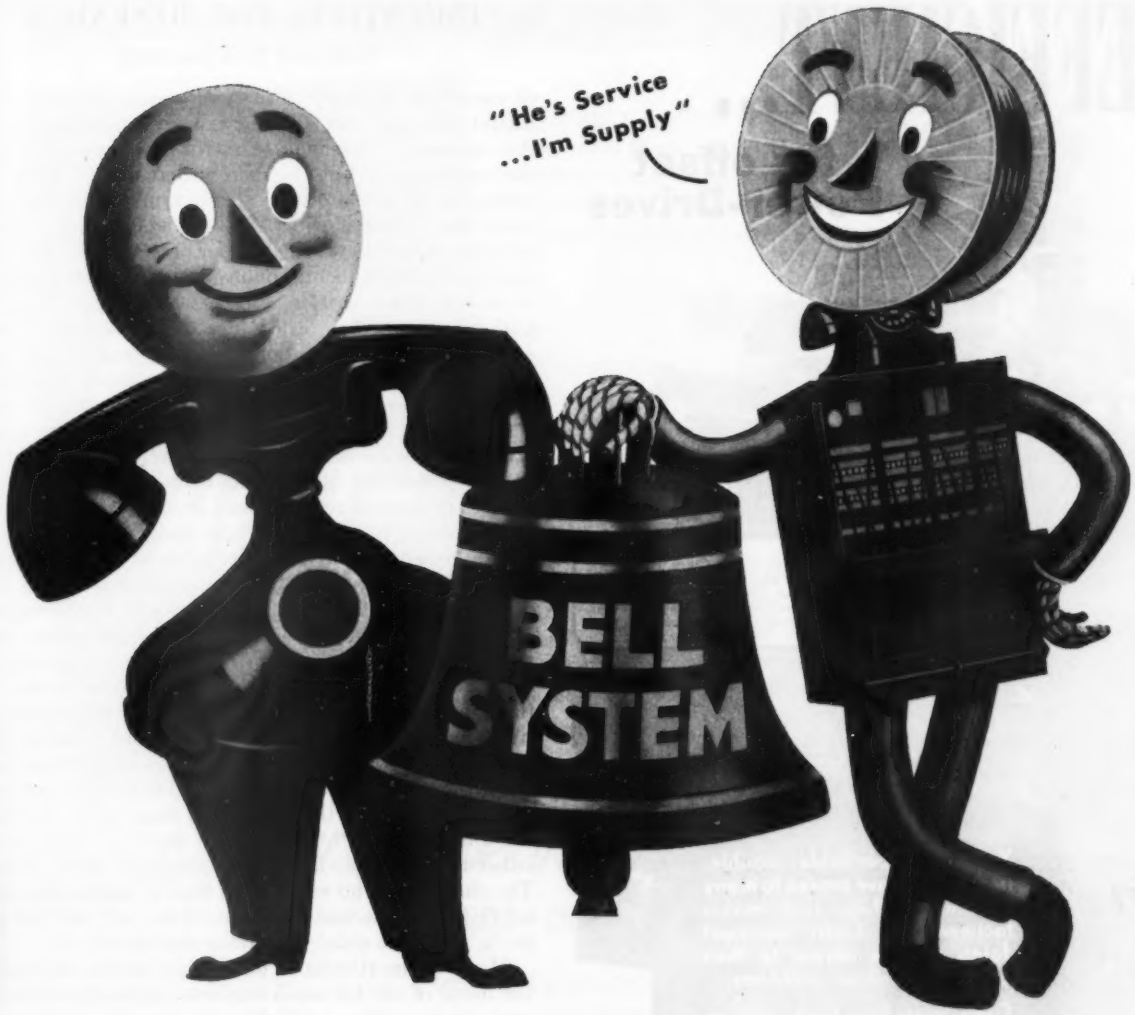
The L-S Power Jacklift, built in both Platform and Pallet types, combines all the good features so long needed for economical, efficient materials handling by power, — *Complete Finger-Tip Control* insures maximum speed and maneuverability with *Safety . . . Electric Brake* applies instantaneously with release of power, — the quickest, smoothest, most dependable braking control . . . and *Vertical Handle Operation* permits use in congested areas heretofore inaccessible with this type of equipment.

TWO SPEEDS FORWARD . TWO SPEEDS REVERSE . ELECTRIC POWER LIFT . ELECTRIC LOWERING . HORN FOR SAFE DRIVING . INDIVIDUAL LOCK . ELECTRIC BRAKE

LEWIS-SHEPARD PRODUCTS INC.
251 WALNUT STREET
WATERTOWN 72, MASS.

MULTIPLY MANPOWER LEWIS-SHEPARD TRADE MARK

SINGLELIFTS . HYDRAULIC HANDLIFT TRUCKS . JACKLIFTS . SKIDS . FLOOR TRUCKS . PALLET TRUCKS . STACKERS . PALLET STACKERS
PRODUCTION LIFTERS . CRANES . RACKS . ELECTRIC, GAS-ELECTRIC AND GASOLINE POWERED FORK TRUCKS . POWER JACKLIFTS



"Teamed-up for you since '82"

"WE'RE symbols of a unique industrial team that has been working for you for 65 years. With our research teammate — Bell Telephone Laboratories — we've helped to give you the world's best telephone service at the lowest possible cost.

"My part of the job is to supply high quality products that meet exacting standards.

"I *manufacture* telephone equipment... *purchase* all manner of supplies for Bell Telephone Companies... *distribute* equipment and supplies to them from stocks maintained at my factories and my 29 warehouses ... *install* central office equipment.

"Right now, I'm providing more telephone equipment and supplies than ever before. Using all my knowledge and skill, gained through years of experience, I'm going at top speed to catch up with the greatest demand on record.

"Remember my name... it's Western Electric."

MANUFACTURER... of 43,000 varieties of telephone apparatus.

PURCHASER... of supplies of all kinds for telephone companies.

DISTRIBUTOR... of telephone apparatus and supplies.

INSTALLER... of telephone central office equipment.

Western Electric

A UNIT OF THE BELL SYSTEM SINCE 1882

EFFICIENT...

for offset Power-Drives

Two 2" C652 Curtis Universal Joints used in transmitting power through offset main drive of milling machine made by The Producto Machine Co., Bridgeport, Conn.

Years of dependable, trouble-free service have proven to many leading machine tool manufacturers that Curtis Universal Joints are the answer to their offset power-drive problems.

Curtis Joints have fewer parts — no threads to work loose and are precision fitted in assembly to insure a smooth, positive-action joint that gives maximum life with minimum maintenance — factors of real importance in power drives.

Available in 14 standard sizes from 3/8" to 4", either single or double. Quotations on special sizes, bores or tolerances gladly made, upon request.

Write for Engineering Data and drafting templates.

WRITE DEPT. B-5

CURTIS UNIVERSAL JOINT CO. INC.

INCENTIVES FOR RESEARCH

(*Continued from page 219*)

of something he might otherwise keep to himself. If we should take away most of the reward for disclosure, and thus encourage reversion to secret processes, the loss to our country would not be merely that due to less widespread use of new processes. There would be even greater losses due to the slowing down of the exchange of basic information and new ideas. Under present conditions new discoveries are frequently published long before the patent is issued, which accelerates the whole tempo of industrial progress. When a new idea can immediately breed other new ideas, inventions multiply rapidly. Prompt disclosure of scientific information stimulates researchers in fields not even dreamed of by the original discoverer.

On the other hand, without an effective patent system early publication of industrial research work would seldom be permitted. Meetings and conferences of technical experts in applied research and progress reports on new lines of development would practically cease. Industrial espionage would rear its ugly head, and the efforts to prevent it would eliminate the open-door policy of most of our industrial laboratories. Charles F. Kettering once aptly said: "When you lock the research laboratory door, you always lock out a great deal more than you lock in."

Another unfortunate result of secret processes would be that small companies would no longer be able, as prospective licensees, to get full information and detailed plans on competitive new processes before deciding on any one. Even though the owners were willing to sell knowledge of a secret process, they could not make prior disclosure for comparison with others. The small company would either have to buy an unknown quantity or do without. The charlatan, who would then have a reasonable excuse for failing to disclose details until he had sold his gold brick, would be aided by a reversion to secrecy.

Many of the attacks on our patent system are made in the name of aid for small business. Actually, weakening our patent system and driving research underground would harm small business far more than it would big business.

Freedom, Incentives, Man Power

The inability to patent new devices would particularly handicap certain fields of engineering research. In chemistry, where a new process may depend upon temperature, pressure, or other reaction conditions which do not appear at all in the finished product, there is often a good prospect of keeping a process secret. It is therefore worthwhile to put time and money on developing such a process, even in the absence of a patent system. In most engineering fields secrecy is impossible. An automotive engineer who develops a new engine or a new hydraulic brake can keep his invention secret only until the day when the first car using it appears on the market. From then on any other automotive engineer can easily copy it, unless it is protected by patents. Without patents, incentives for research in most engineering fields would be greatly curtailed.

What, then, needs to be done to insure that research and science will aid our country as much during the next quarter century as during the past one? To overcome the various threats to the future of research which I have

(*Continued on page 234*)

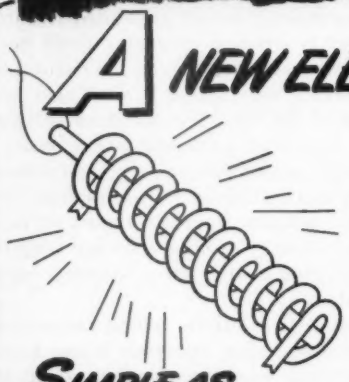
THE MARCH OF SCIENCE

MIRACLE HEAT— without fire or furnace!

HEATING A PIECE OF METAL BY OPEN FLAME, BLOW-TORCH OR FURNACE IS RELATIVELY SLOW— APT TO LEAVE SCALE... IT'S HARD TO HEAT ONE SPECIFIC AREA WITHOUT HEATING THE WHOLE PIECE.

PRODUCTION MEN REALIZED HEAT-TREATING OPERATIONS SUCH AS FORGING, PRECISION BRAZING AND SURFACE HARDENING COULD BE STEPPED WAY UP IF A FASTER METHOD OF HEATING COULD BE FOUND... ONE WHICH WOULD CONCENTRATE THE HEAT AT PRE-SELECTED AREAS!

HEAT BY INDUCTION SEEMED LIKE THE ANSWER. SCIENCE HAD ALREADY DISCOVERED THAT METALS HEAT RAPIDLY WHEN INTRODUCED INTO A HIGH FREQUENCY, HIGH DENSITY MAGNETIC FIELD!



A NEW ELECTRONIC HEATER DESIGNED BY ALLIS-CHALMERS SCIENTISTS—

AMAZING PRODUCTION TOOL RECTIFIES ORDINARY 60-CYCLE CURRENT THEN STEPS IT UP TO 450,000 CYCLES. A MAGNETIC FIELD OF HIGH DENSITY IS SET UP IN WORK COIL AND WHEN METAL IS INTRODUCED INTO THIS FIELD, PASSAGE OF CURRENT CAUSES POWER LOSSES WHICH PRODUCE HEAT WITHIN THE METAL WITH INCREDIBLE SWIFTNESS.

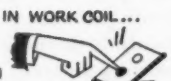
BIG BENEFITS: COMPLETE, SELECTIVE CONTROL OF HEAT PENETRATION... EXACT UNIFORMITY... GREATLY INCREASED PRODUCTION!

SIMPLE AS

A PLACE METAL IN WORK COIL...

B PUSH BUTTON

C METAL IS HOT IN SPLIT SECONDS



ALLIS-CHALMERS MANUFACTURING CO. MILWAUKEE 1, WIS.

ELECTRONIC HEATER IS ONE MORE EXAMPLE OF HOW ALLIS-CHALMERS RESEARCH AND EXPERIENCE GO TO WORK FINDING BETTER, FASTER, MORE EFFICIENT WAYS OF HANDLING PRODUCTION PROBLEMS—ANOTHER GOOD REASON WHY A-C EQUIPMENT IS IN DEMAND IN EVERY MAJOR INDUSTRY...

ALLIS CHALMERS

ONE OF THE BIG 3 IN ELECTRIC POWER EQUIPMENT
BIGGEST OF ALL IN RANGE OF INDUSTRIAL PRODUCTS

Gasoline spills on *your* fender leave ugly stains . . . but don't blame the attendant! Many cars cannot receive gas at full pumping speeds, and the attendant has no way of knowing when the tank is filled.

VENTALARM is the answer!

VENTALARM, in the gas tank, whistles while it works . . . the attendant can fill speedily, without danger of over-filling, as long as he hears the VENTALARM whistle. When it stops, he stops filling!

VENTALARM:

- *protects car finish from unsightly gas stains*
- *eliminates spills . . . saves time and money*
- *provides for safety expansion zone in tank*
- *minimizes danger of flash fires*

VENTALARM is standard equipment on Packard Clipper, Chrysler Imperial, Willys Station Wagon, and 12 makes of buses, trucks and taxicabs.

If you would like a VENTALARM for your car just write us. We will be happy to send you one, with our compliments, together with installation instructions.

*A million oil-heated homes enjoy VENTALARM fuel oil delivery. Driver never enters home . . . ask your oil company!

SCULLY SIGNAL COMPANY
CAMBRIDGE 41, MASS.
FRANK P. SCULLY, '15, President

VENTALARM
THE GAS TANK FILL SIGNAL

INCENTIVES FOR RESEARCH

(*Continued from page 232*)

mentioned and which, make no mistake, are in the aggregate very serious, we need three principal things: first, sufficient man power; second, freedom of opportunity; and third, specific incentives for certain special cases.

To help overcome the shortage of properly trained man power, a sound government scholarship and fellowship program must be adopted and carried out. In addition to the help afforded veterans by the veterans' Bill of Rights, we must make sure that every man who is well qualified for scientific training is encouraged to complete his scientific education, and is permitted by Selective Service to do so.

An excellent program of government aid for scientific education and basic research was laid out in the report made to the President of the United States by Dr. Bush. In the last Congress that program failed of enactment into law largely because certain politicians and Washington bureaucrats insisted on trying to make the proposed National Science Foundation a new stronghold of bureaucracy. It is hoped that a sensible bill can be passed by the present Congress.

In order to furnish adequate opportunity and incentive for continuation of research, different things are required in various fields. I shall endeavor to summarize what seem to me the prime essentials in each major field.

Research by the Larger Industrial Companies

The main requirement for an expanded research program in industry is freedom. Industry must be free to work in its own way and free to reap the natural rewards from any advances it may make. It must also be free to try to get ahead of the other fellow, which is the essence of competition. Under such circumstances business men who make decisions about risking money on research will strike out boldly and with imagination, hoping to improve their competitive position, increase their profits, or find new ways to make money. Competition is a whip or goad, and profit an inviting goal, when a business manager is free to choose the way.

If government is to continue telling business what it can or must produce, what materials it can have, what prices it may charge, what licenses it must grant, what wages it must pay, and if government is to continue taking the lion's share of the profits in the form of taxes, there is certainly little incentive to expand our research and development programs.

Likewise, research can be discouraged by government domination or dictation of research programs or by government competition in industrial research. If the government does an adequate job of encouraging basic research and supporting military, public health, and agricultural research, it will have its hands more than full for many years to come. Tax-supported research in competitive industrial fields is essentially unfair competition and will discourage far more private research than the government could possibly carry out. Industrial research has been one of the outstanding achievements of our free enterprise system, and can thrive only in such an atmosphere.

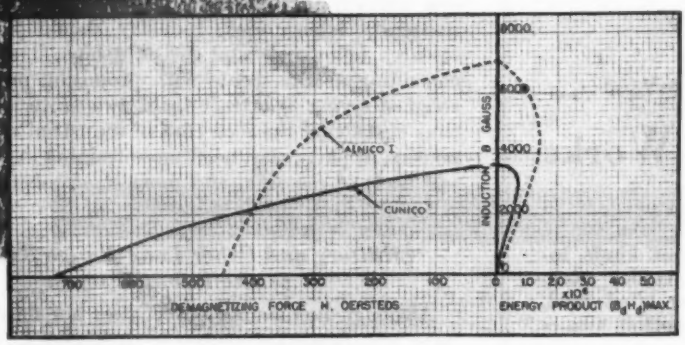
Nor do we need to worry about the way in which large companies will conduct themselves in an atmosphere of

(*Continued on page 236*)

GENERATOR ROTORS CAN BE OPERATED SAFELY AT *125,000 RPM*

Cunico is the newest addition to the Arnold high quality permanent magnet line. It is a copper nickel cobalt alloy which has very high coercive force. Ductile, machineable and malleable, Cunico can be fabricated into a wide variety of simple and complex designs. Drawing, cutting, machining, punching and screw machine operations are practical.

Cunico can be magnetized in any direction, and is most efficient where a large cross section is available to produce sufficient total flux. Generator rotors are a typical application. A relatively short length is required to maintain the flux because of its high coercive force.



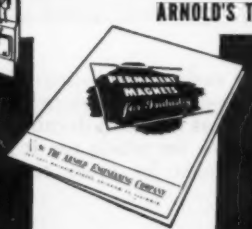
CUNICO CAN BE PRODUCED IN THE FOLLOWING SHAPES AND APPROXIMATE SIZES:

***BARS*—¼" to 1" square**
***STRIPS*—2" maximum width x .015" to .312" thickness**
***RODS*—¼" to 1" in diameter**
***WIRE*—No. 2 to No. 24 AWG sizes**
***CASTINGS*—Maximum section 1" thick**

Write today for details.

THE ARNOLD ENGINEERING COMPANY

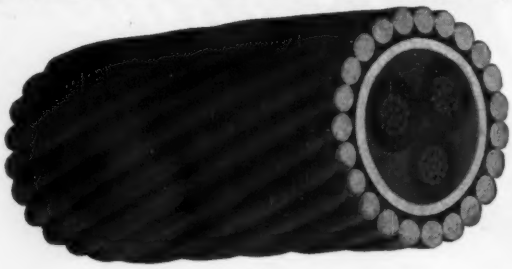
SUBSIDIARY OF ALLEGHENY LUDLUM STEEL CORPORATION
147 EAST ONTARIO STREET, CHICAGO 11, ILLINOIS
Specialists in the manufacture of **ALNICO PERMANENT MAGNETS**



ARNOLD'S TECHNICAL BULLETIN

"Permanent Magnets for Industry" suggests many ways in which the war-born improvements in permanent magnets can be most valuable to you. Send for it!

ONE AMONG THOUSANDS



OF

POWER CORDS AND CABLES

designed by Simplex to meet unusual service requirements.

Can we help you with your problems?

Call KIRkland 9000

SIMPLEX WIRES AND CABLES

SIMPLEX WIRE & CABLE CO.
79 Sidney St., Cambridge 39, Mass.

Reg. U. S. Pat. Off.

Samson Cordage Works

Boston 10, Mass.

Manufacturers of braided cords of all kinds, including sash cord, clothes line, trolley cord, signal cord, shade cord, Venetian blind cord, awning line, etc., also polished cotton twines and specialties.

SPOT CORD

Reg. U. S. Pat. Off.

Our extra quality sash cord, distinguished at a glance by our trade-mark, the colored spots. Especially well known as the most durable material for hanging windows, for which use it has been specified by architects for more than half a century.

INCENTIVES FOR RESEARCH

(*Continued from page 234*)

freedom. They are aware of their social responsibilities, and those which are not, are aware of the scrutinizing eyes of their customers. President Karl T. Compton has recently noted on the part of industry an "increasing interest in fundamental research, a more liberal interpretation of company policy, and an increasing tendency to co-operate with other companies in the industry or with universities." But industry must have at least a chance to make good profits from ventures which turn out to be successful, in order to offset the increasing cost of the failures.

Industrial Research by Small Companies, Foundations, and Universities

As I have indicated previously, to stimulate industrial research by other than large operating companies, it is essential to assure adequate incentives outside of operating profits. Our patent system is the best method ever devised, because the reward depends on the actual importance of what a man discovers. However, attacks on our patent system and some of our courts have weakened the protection afforded, particularly to the independent inventor who cannot afford a long-drawn-out litigation. John Anderson, an independent inventor of note, has said: "People seldom plant gardens where thieves abound." It is high time we again recognized the tremendous part which our patent system has played in encouraging research and invention. As Lincoln did when he made the statement, we must recognize that "the patent system has added the fuel of interest to the fire of genius."

Basic Research in Our Universities

In addition to strengthening our universities for their training functions, it is important that both government and industry increase their support of basic research in university laboratories. Industry should finance more research fellowships and assistantships; it should make consulting arrangements with promising professors, instead of trying to attract them away into industry and thus destroying the seed corn of industrial research. Engineers, in particular, need more training in the methods and tools of research, and more encouragement to take advanced work at our universities.

Military and Other Long-Range Research in the Public Interest

Although neither the universities nor most industries have any particular incentive to engage in military research, intensive research along those lines is essential to our national security, at least until we can be more certain of continuing world peace. Equally important is research to develop substitutes for raw materials not available in this country or to study long-range problems affecting our national security. Such research will be done on an adequate scale only if the government finances it. While there will be need for some centralized government laboratories in some of the above mentioned fields, experience between the two wars has indicated that government laboratories which do not maintain close contact with active industrial research are very likely to get into ruts and seldom make far-reaching advances. Of a list of

(*Concluded on page 238*)

DECADES OF EXPERIENCE

in
PROCESSING
DESIGN
ENGINEERING
CONSTRUCTION

for the
PETROLEUM
CHEMICAL
PETRO-CHEMICAL
INDUSTRIES

E. B. Badger & SONS CO. • EST. 1841

BOSTON 14 • NEW YORK • SAN FRANCISCO • LOS ANGELES • LONDON • RIO DE JANEIRO

TRADE MARK
HEVI DUTY
REGISTERED U. S. PAT. OFFICE

Hevi Duty Electric Co.

Electric Furnaces

MILWAUKEE, WISCONSIN

Hevi Duty Precision Electric Heat Treating Furnaces are built in a large variety of types and sizes — for many heat treating operations — with temperature ranges to 2500° F. (1371° C.). They are standard production equipment in many national industrial plants.

Write for descriptive bulletins

HAROLD E. KOCH '22, *President*

ELTON E. STAPLES '26, *District Manager, Cleveland*

HEVI DUTY ELECTRIC COMPANY
HEAT TREATING FURNACES - HEVI DUTY ELECTRIC EXCLUSIVELY
MILWAUKEE 1, WISCONSIN

KNOW CO_2

AND ITS MANY HELPFUL APPLICATIONS

Write for this free check-list today... it's yours for the asking. Every potential user of DRY ICE and CO_2 should have a copy for reference . . . it offers suggestions for possible applications to your problems or processes. See how other industries put DRY ICE and CO_2 to work for them. Many applications, perhaps, can be adapted to your needs. New uses are discovered constantly.

Liquid RED DIAMOND Gas and Dry Ice

THE LIQUID CARBONIC CORPORATION
3110 South Kedzie Avenue
Chicago 23, Illinois
Branches in Principal Cities of the United States and Canada

INCENTIVES FOR RESEARCH

(*Concluded from page 236*)

the 18 most important American inventions compiled by the United States Patent Office with the assistance of the leading American scientists, industrialists, and statesmen, not a single one was made in a government laboratory!

If such laboratories are to do a good job in the future, they must maintain outside contacts, rotate their personnel, and farm out many of their projects to laboratories which are particularly qualified to follow certain lines of investigation and to supply new points of view. The new Navy research program emphasizes such farm-out contracts and seems particularly well adapted to achieve good results.

Research in Public Health, Agriculture, and Forest Products

In several fields endowed with substantial public interest the commercial operations are private enterprises but are generally on such small scale that adequate research is not likely to be carried out. The fields of agriculture, public health, and forest products are cases in point. In these fields, government research has already achieved substantial success, but the work should be broadened, more adequate salaries should be paid, and more projects should be farmed out to university and industrial laboratories. Industry has the advantage of being trained to get a specific answer in a limited time instead of allowing researches to drag out indefinitely, as so often happens in government laboratories.

In spite of the clouds on the horizon, the achievements of research, both in peace and in war, are so great that research is bound to go ahead. If the public can be made to understand the need for adequate incentives and opportunities, we shall witness an era of scientific achievement which will dwarf that of the past. The confidence of industrial organizations in our country's future is to be seen in the amazing number of outstanding new laboratories which are under construction or have been announced.

Let us not become imbued with the idea, however, that research will flourish no matter what environment we provide for it.

We must use wisdom in maintaining a favorable environment for American research. While industry rather generally concurs with our leading scientists in urging government aid for basic research and training activities, it needs neither government aid nor any fancy new incentives in most fields of industrial research. If we will but wind up the barbed wire, burn up the red tape, and let the old incentives of hope for profit and for individual advancement get back into full operation, you may be confident that our free enterprise system will far outstrip its past achievements in the fields of research and invention.

Plan to attend the midwinter meeting of the Alumni of Metropolitan Boston, to be held the evening of Saturday, February 8, in Walker Memorial. President Compton and Dean Baker will be present. Dr. V. K. Zworykin, Associate Director, RCA Laboratories, will explain and demonstrate a complete black and white television system.

FOR TOP PRECISION

in measuring Angles and Locating Work

...use these TAFT-PEIRCE Toolroom Specialties

Sine Bar — For measuring angles accurately or locating work to a given angle within close limits. Available in 3", 5", 10", and 20" sizes.

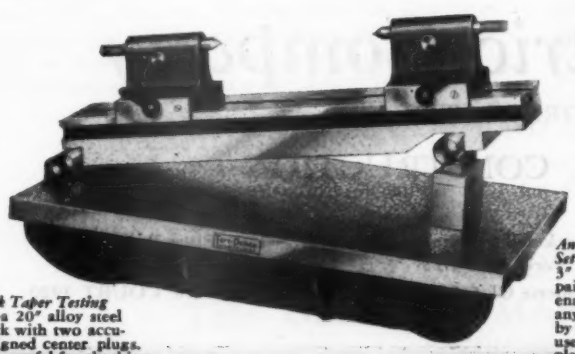
Sine Block—Combines the features of the 5" sine bar and a right-angle iron. Tapped holes in the block simplify clamping of work.

These tools are but a few of those available from Taft-Peirce stock for measuring angles and locating work to a given angle with the utmost accuracy. Tops in their field, they are a product of the Taft-Peirce Small Tool and Gage Division, and are indispensable for inspection and set-up departments in maintaining high standards of accuracy.

For further details of these and other angle-measuring equipment, write today for the new Taft-Peirce Handbook.

THE TAFT-PEIRCE MFG. COMPANY
WOONSOCKET, RHODE ISLAND

Sine Bar Fixture — A sine bar, clamping device, and base constructed as a single integral tool. Available in 5 and 10" bar sizes. Invaluable in machining, grinding, and inspection departments.



Sine Block Taper Testing Fixture—a 20" alloy steel sine block with two accurately aligned center plugs. Especially useful for checking tapers with extreme precision.

Angle Block and Sine Bar Set — This set comprises a 3" sine bar and thirteen pairs of 4" angle blocks, enables the user to create any angle from 0° to 90° by ½° increments. Ideal for use on magnetic chuck face plate.

The

RUMFORD PRESS

CONCORD
NEW HAMPSHIRE

WHERE

Printing

IS STILL A CRAFT

William H. Coburn, '11 William F. Dean, '17

William H. Coburn & Co.

INVESTMENT COUNSEL

68 Devonshire St. Boston, Mass.

SCIENCE, INDUSTRY, AND GOVERNMENT

(*Continued from page 216*)

In answer to these questions I do not pretend to be able to give a simple formula which would be applicable to all cases. But extreme views have been expressed in Britain on this subject.

It has been argued by some that all science investigations should be made in a central scientific department and none in the executive departments. It has been correspondingly argued by others that each executive department should have sufficient scientific staff to make all the research which it needs in the discharge of its own responsibilities. There are weighty economic reasons for the use of some, even if not all, common scientific services.

But, granted that there are some central scientific services, how can we insure that their work can be effective in the executive departments? It seems to me entirely unfair to expect the normal administrative staff of such departments to play the full role of user.

One solution of this difficulty is the appointment of a scientific advisor in each executive department who can identify the problems within his department which are suitable for scientific treatment, see that these problems are passed to the appropriate research bodies able to solve them, and interpret the incoming scientific material for the special purpose of his department. But I should stress that for such a scientific advisor to be effective it is necessary that he should be sufficiently senior in the department hierarchy. His advice should be tendered to the highest level — the level at which policy is decided.

I have so far stressed the value of the work of D.S.I.R. to government and, through government, to the community. But there is also another link with the community, and that is through industry. In this connection the Department serves industry chiefly by conducting research on generic fundamental problems on the basis of which industry itself can make applications. The greater part of this research is what I called objective fundamental research. In this case the main quest is understanding. Here the scientist seeks physical or chemical insight, and even atomic insight, into certain fields of practical importance. This may relate to the corrosion of metals, the oxidation of fats, the toughness of meat, the warping of wood, the electronic changes in the ionosphere, and so

(*Continued on page 242*)

Lord Electric Company

INCORPORATED

ELECTRICAL CONSTRUCTION

131 Clarendon Street
Boston 16, Massachusetts
Telephone COM 0456

10 Rockefeller Plaza
New York 20, N. Y.
Telephone CI 6-8000

1201 Plaza Building
Pittsburgh 19, Pa.
Telephone COURT 1920

Beginning, in many institutions, with members of the Class of 1818...and going right on, class after class, to the present day...Brooks Brothers have supplied ever-changing Clothes and Accessories which, through 128 years, have continued to win the particular approval and the special endorsement of Alumni, College Undergraduates and Students at Preparatory Schools everywhere.

46 NEWBURY STREET,
BOSTON 16, MASS.

714 SOUTH HILL ST.,
LOS ANGELES 14, CALIF.

111 SUTTER STREET,
SAN FRANCISCO 4, CALIF.

Brooks Brothers,
CLOTHING,
Men's Furnishings, Hats & Shoes
OFFICERS' UNIFORMS, FURNISHINGS AND ACCESSORIES
346 MADISON AVENUE, COR. 44TH STREET, NEW YORK 17, N. Y.

Unusual opportunity for

ELECTRONICS ENGINEERS
PHYSICISTS • MATHEMATICIANS
AERONAUTICAL ENGINEERS!

If you feel that your present connection does not offer maximum opportunity for expansion, here's your chance to go places in aviation, a field with a future! The Glenn L. Martin Co. has available a number of excellent positions . . . paying $300 to $600, depending on experience . . . for men with advanced college training and development experience. Interesting research work on Guided Missiles, Pilotless Aircraft, Fire Control Systems and Electronics Equipment. Unusually complete engineering and laboratory equipment . . . millions of dollars in contracts for research and development in the electronics, missile and propulsion fields.

This is your opportunity to break away from monotonous routine and give full scope to your research ability. Associate now with America's foremost aircraft manufacturer, holding nearly one-fifth of all the aircraft orders in the nation . . . a company with a $201,000,000 backlog of orders in such diverse fields as military aircraft, commercial aircraft, ground equipment, plastics, photography, gun turrets, etc. Write today, outlining your experience, and find out what Martin can offer you.

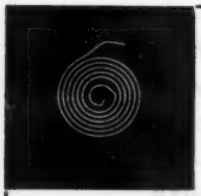
OTHER WELL-PAID OPENINGS

Engineers also needed as Draftsmen, Designers, Stress Analysts and Aerodynamicists. These are not just jobs, but well-paid careers with big futures.

WRITE IMMEDIATELY TO:

TECHNICAL EMPLOYMENT SECTION
THE GLENN L. MARTIN COMPANY
BALTIMORE 3, MD.

J. C. CORRIGAN CO.
Conveyers
Engineers • Manufacturers • Erectors
Coal Handling Systems
Materials Handling Equipment
Portable Conveyors
Distributors for
Jeffrey Manufacturing Co.
Jeffrey Parts Carried in Boston Stock
41 Norwood Street, Boston, Mass.
Tel. GENeva 0800



PRECISION-GAUGED HAIRSPRINGS AND FINE ROLLED WIRE
PRECISION PRODUCTS COMPANY
WALTHAM, MASSACHUSETTS
ROBERT I. BRADLEY '20

THE TRIAL IS NEVER OVER

GOOD-WILL is the disposition of the customer to return to the place where he has been served well—
U. S. Supreme Court.
TO OUR FRIENDS
We do not believe that any advertising copy man could have penned a neater nd more trenchant definition than this decision of the Supreme Court.
It happens also to be the verdict which our customers have reached regarding their relations with us.
Your specific problems in technical reproduction work from the lowly blue print to the complicated offset printing of an engineering manual, will find their happy solution with us.
ELECTRO SUN COMPANY, INC.
Blue Prints—Photo Prints—Photo Offset
161 Washington Street 157 Chambers Street
Grand Central Terminal Building
NEW YORK, N. Y.
A. L. Weil '01 J. C. Duff '86

SCIENCE, INDUSTRY, AND GOVERNMENT

(*Continued from page 240*)

on. Armed with understanding, many practical problems are relatively easily solved. Very often a basic attack of this kind is the most fruitful and shortest route to the solution of a problem of practical importance. Also, very often quite unexpected and unsought applications are thrown up as by-products of such fundamental research.

Industrial Research

I now turn to the subject of industrial research which is conducted in Britain by private firms and by the industrial research associations. The larger firms, to an increasing extent, have their own laboratories, some of which are comparable in size and scope to the larger government research laboratories. But these laboratories exist mainly in the newer industries which were, in any case, born and bred on science and to whom scientific research is the life blood. In many cases such firms carry out not only applied research, but also objective fundamental research relevant to their own interests. They are, of course, at liberty to keep the results of their scientific work to themselves, but in general they follow an enlightened policy and their staffs are important contributors to the world's scientific literature.

With a view to stimulating research by private firms the British Government has recently introduced certain fiscal changes. For many years now it has been possible for a "trader" to count current revenue expenditure on scientific research undertaken in relation to his trade as a deduction in computing profits for income tax purposes. But as from April 6, 1946, provision has been made whereby capital, as distinct from current, expenditure, is allowable for income tax purposes by five equal annual installments. For this purpose capital expenditure may relate, for example, to the building of research laboratories or the installation of pilot plants.

It is admitted that research always pays a dividend if you do enough of it. But in considering industrial research in Great Britain, we are at once faced with the fact that more than 98 per cent of our firms employ less than 100 workers. To a small firm without considerable financial reserves industrial research on its own account must often appear as a risky adventure and beyond its means. This difficulty has been met to a considerable extent by the D.S.I.R. which is charged with the duty of encouraging research in industry.

The main method by which we have done this is by the formation of research associations, each on a co-operative basis, to serve the needs of particular industries. These research associations are self-governing bodies formed on a national basis. They are financed mainly by the contributions of their member firms but are also supported by substantial grants from the D.S.I.R., the size of which is related to the amounts raised by the industries themselves.

There are now 35 or more of these research associations and their expenditure on research is nearing £1,500,000 per year, having risen from a little more than £250,000 in 1934 to £500,000 just before the war. It would not be at all surprising to see this figure more than double in the next few years.

(*Continued on page 244*)

Investment Consultation Service

An Investment Consultation Account is one in which you employ the Investment Division of our Trust Department to advise you in the investment of your property. It is purely advisory; you continue to keep your own records and to handle your own securities. Its purpose is to help you establish a sound, well-balanced investment list.

Our Consultation Service offers you:

1. A review of your securities every three months, with recommendations for sales and purchases.
2. Continuing watchfulness by our organization for developments affecting your stocks and bonds and, when desirable, suggestions for changes.
3. Consultation with us in regard to your investments at any time.

Our officers will be glad to explain this service to you in detail.

The

New England Trust Company

135 DEVONSHIRE STREET

At the Corner of Milk Street

BOSTON 7, MASS.

Member Federal Reserve System

WILLIAM D. NEUBERG COMPANY

Chemicals

GRAYBAR BUILDING 420 LEXINGTON AVE.
NEW YORK 17 N. Y.
TELEPHONE LEXINGTON 2-3324

SWISS AUTOMATICS

Rebuilding and Tooling Service

We have trained personnel and facilities for complete rebuilding and tooling of your Swiss Automatics and other type Swiss Machines.

YOUR INQUIRIES ARE INVITED

BORIS M. VOLYNSKY MFG. CO., INC.
311 West 66th Street New York 23, N. Y.

Surface

PYROMETERS

for every purpose

The routine use of CAMBRIDGE Surface Pyrometers takes the guesswork out of temperature determination in many industries. The CAMBRIDGE is accurate, dependable, rugged, quick-acting and easy to use. The Roll Model is for checking surface temperatures of still or moving rolls. The Needle Model is for insertion into materials in a plastic or semi-plastic state for within-the-mass temperature determination. The Mold Model is for checking surface temperatures of mold cavities and surfaces of almost any contour.

Send for Bulletin 194SA.

CAMBRIDGE INSTRUMENT CO., INC.
3707 Grand Central Terminal
New York 17, N. Y.

CAMBRIDGE
PIONEER MANUFACTURERS OF
PRECISION INSTRUMENTS

Moisture Indicators and Recorders • Physical Testing Instruments
Surface Pyrometers • Laboratory Instruments for A. C. & D. C. • Galvanometers
Engineering Instruments • Gas Analysis Equipment • Physiological Instruments
and many other Mechanical and Electrical Instruments

SCIENCE, INDUSTRY, AND GOVERNMENT

(*Continued from page 242*)

For a very modest contribution — less than the cost of a single junior research worker — a small firm is enabled, by joining a research association, to share in research costing thousands of pounds, and in some cases hundreds of thousands of pounds a year. The research associations also keep their members informed on scientific and technical developments throughout the world, provide them with advice on their day-to-day problems, and insure that the industry as a whole has an opportunity of receiving early knowledge of developments likely to affect the future of their industry.

One thing which I am afraid tended to hinder the growth of co-operative research in the past was the rather touching belief of many firms that they possessed knowledge and trade secrets which were unknown to their competitors, and that this might be revealed if they collaborated in research. The manner in which firms had to work together in the war has done much to destroy this fear. An interesting side light on this matter are the remarks of the managing director of one of our leading aircraft firms. He said, "When the war began we thought that we knew a great deal more than our competitors, but when we were forced to share our knowledge with them we found they knew just about as much as we did and that the gaps in their knowledge and ours were about the same. What surprised us all still more was that when we had to share our knowledge with our American allies we again found that the gaps in their knowledge and ours were just about the same."

To Serve An Understanding Public

Perhaps I may be permitted to devote the last section of my discourse to personal views rather than to factual matters. I strongly believe that the scientific life should be one of intellectual adventure. It seems to me that this can characterize it whatever its objective. We must recognize and encourage the enthusiasm of the chase as well as the attainment of the objective. We need to break down the old false barrier between the so-called pure and applied divisions of science, for the whole field is essentially one and its parts are interdependent. We are sometimes sufficiently aware of possible practical applications not too far distant for such recognition to influence our choice of subject. But we must beware of too much restriction of the scientific front. That is the way of arrogance and folly. Man is not all prescient; and nature has many surprises.

As to the scientist himself, I believe that he should serve, and not dictate to, mankind. But he has the important dual mission, not only of uncovering nature, but also of interpreting it to his fellow men. If the conse-

(*Concluded on page 246*)

Transits and Levels are used on all largest works and by U. S. Govt. for utmost precision. Rental Insts. *New catalog, just issued, sent gratis. A souvenir plumb-bob sent for 3¢ postage.*

BUFF & BUFF CO. **Boston 30, Mass.**
Henry A. Buff '05

McCREERY and THERIAULT

Building Construction

126 NEWBURY STREET BOSTON, MASS.

THE MURRAY PRINTING COMPANY

A Complete Printing Organization
Letterpress :: Offset :: Binding

18 AMES STREET
CAMBRIDGE

BATH IRON WORKS CORPORATION

Shipbuilders and Engineers

•

BATH, MAINE

If It's Made — Ask ALBERT!

FOR IMMEDIATE DELIVERY
Odd and Large Sizes a Specialty
⅛" to 72"
LARGEST AND MOST COMPLETE STOCK on Atlantic Seaboard
Shop Facilities for: Threading and Welding — All Sizes of Pipe — Welding Fittings and Flanges, ½" to 24" Dia.
ALSO RECONDITIONED PIPE — VALVES — FITTINGS FOR TEMPORARY SERVICE

● PIPE
Electric Weld
Seamless
Spiral Weld
Lap Weld
Butt Weld
Steel—Wrought Iron
Shore-Dredge

● VALVES
Iron Body
Forged Steel
Cast Steel
and
Special
Alloys

● FITTINGS
Welding
Tube Turns
Fabricated
Cast Iron
Forged Steel
Cast Steel Dresser
Malleable Victaulic

● PILING
ARMCO
Youngstown
Points — Sleeves
all Specifications

•

S. G. ALBERT '29
Treasurer

ALBERT PIPE SUPPLY CO., Inc.
No. 13th & Berry Streets, Brooklyn, N. Y. EVergreen 7-8100

LOUIS LONG, JR., PH.D.
CONSULTING CHEMIST
REPORTS • SURVEYS • RESEARCH
53 STATE STREET, BOSTON, MASS.

SYSKA & HENNESSY
Engineers
Consultation Plans Reports
Power Plant Disposal Plants
Water Systems
NEW YORK, N. Y.
J. F. HENNESSY '24

MONSANTO CHEMICAL COMPANY
Merrimac Division
EVERETT
MASSACHUSETTS
The largest and oldest chemical manufacturer in New England

LEONARD CONSTRUCTION COMPANY
Engineers and Contractors
SINCE 1905
IN ALL THE AMERICAS AND FAR EAST
37 South Wabash Ave. Chicago
420 Lexington Ave. New York City
Ingenerios S.A. de C.V., Mexico

SCIENCE, INDUSTRY, AND GOVERNMENT

(*Concluded from page 244*)

quences of scientific effort are understood by the community, any vital decisions on use must be taken together. Science is too serious a matter to be left to the scientists.

But here I am bound to confess that I see a certain danger, at any rate in my own country. I cannot but feel that there is a tendency in our educational system for scientific specialization to be introduced too soon. A scientific man should also be the complete citizen of the world. He should not only be fit to live, but also fit to live with. This can only be brought about if his later specialized training is based, and continues to be based, on a broad cultural background. Only in this way can the scientist enjoy the necessary human fellowship with the rest of mankind. With science destined to play such a vital part in moulding the future of our civilization, it seems essential that the public should make its own effort toward understanding science. Too often, and most regrettably, the average citizen is apt to associate science with magic.

As a first step in overcoming these defections I feel that we should start with our educational system which, I think all would agree, should not be merely an implement of vocational training. It is not necessary to be a maker of science in order to understand its history, its content, and its significance. There is a recently published American book which has made a great impression on many minds in my country. It is entitled *A State University Surveys the Humanities* * and consists of a series of essays by members of the staff of the University of North Carolina. Among the many thoughtful and thought-provoking contributions to this scholarly volume there is one entitled "The Biological Sciences: The Sciences in the Humanities" by Dr. Robert E. Coker, who is strongly of the opinion that the general cultural value of science is not sufficiently appreciated in universities. He deplores the cultural distinction which is drawn between the arts and the sciences and believes "it arose and has persisted in part from the over-confidence of some scientists who have proclaimed a self-sufficiency for science. It derives also from the narrowly restricted vision of those who would teach the sciences as if they were useful only to equip individuals for earning a livelihood or to enable mankind to have more gadgets and physical comforts." In another passage in the same essay, Dr. Coker enunciates his main thesis simply and boldly. "The sciences," he claims, "take high rank among the humanities." I believe he is right if the sciences are taught as they could be and should be.

* Chapel Hill, North Carolina: The University of North Carolina Press, 1945. 276 pages. $4.00.

PREPARATORY SCHOOLS FOR BOYS

CHAUNCY HALL SCHOOL
Founded 1828. The School that confines itself exclusively to the preparation of students for the Massachusetts Institute of Technology.
FRANKLIN T. KURT, *Principal* 553 Boylston Street, *Boston, Mass.*

HUNTINGTON SCHOOL FOR BOYS
Grades Nine to Twelve.
Thorough preparation for entrance to M.I.T. and other technical schools.
Regular and summer courses.
320 Huntington Ave., Boston Tel. Kenmore 1800

PROFESSIONAL CARDS

JACKSON & MORELAND
Engineers

Public Utilities — Industrials
Railroad Electrification
Design and Supervision — Valuations
Economic and Operating Reports

BOSTON NEW YORK

H. K. BARROWS, '95
M. Am. Soc. C. E.

CONSULTING HYDRAULIC ENGINEER

Hydro-electric Developments — Water Supplies. Reports, Plans, Supervision. Advice, Appraisals

6 BEACON STREET BOSTON, MASS.

EADIE, FREUND AND CAMPBELL
CONSULTING ENGINEERS

500 FIFTH AVENUE NEW YORK 18, N. Y.

Plans and Specifications — Examinations and Reports

Power, Heating, Ventilating, Electric, Plumbing, Sprinkler, Refrigerating, Elevator Installations, etc., in Buildings and Industrial Plants

J. K. CAMPBELL, M. I. T. '11

STARKWEATHER ENGINEERING CO.
INCORPORATED

Engineers and Contractors for Pumping Plants Boiler and Power Plants, Cooling Water and Heat Recovery Systems

246 Walnut Street, Newtonville BIGelow 8042

Wm. G. Starkweather, M.E. Cornell '92 — J. B. Starkweather, B.S. M.I.T. '21

H. A. KULJIAN & CO.

CONSULTANTS · ENGINEERS · CONSTRUCTORS

Specialists in

UTILITY, INDUSTRIAL and CHEMICAL FIELDS

1518 WALNUT STREET PHILADELPHIA, PA.

H. A. KULJIAN '19

FABRIC RESEARCH LABORATORIES
INCORPORATED

Research, Development and Consultation for Textile and Allied Industries

665 Boylston Street Boston, Mass.

W. J. HAMBURGER, '21 K. R. FOX, '40 E. R. KASWELL, '39

GILBERT ASSOCIATES, INC.
ENGINEERS AND CONSULTANTS

Malcolm G. Davis '25, *Vice President* F. E. Drake '05 — Allen W. Reid '12 E. C. Edgar '35

Steam, Hydro, Diesel Power Plants; Industrial Structures; Plant Safety, Labor Relations, Utility Rates, Valuations, Reports; Large Scale Purchasing; Industrial Laboratory

Reading, Pa. Philadelphia, Pa. — New York 61 Broadway — Washington, D. C. Mexico City

FAY, SPOFFORD & THORNDIKE
Engineers

Airports — Bridges — Water Supply and Sewerage
Port and Terminal Works — Fire Prevention

INVESTIGATIONS DESIGNS
SUPERVISION OF CONSTRUCTION

BOSTON NEW YORK

WALLACE CLARK & COMPANY
CONSULTING MANAGEMENT ENGINEERS
SINCE 1920

Planning for Research and Development, Sales, Engineering, Production, Finance, Industrial Relations, Overall Management

521 FIFTH AVENUE NEW YORK 17, N. Y.

Booklet describing our services and experience will be sent on request

MAURICE A. REIDY
Consulting Engineer

BRIDGES BUILDINGS
STRUCTURAL DESIGNS FOUNDATIONS
CONSTRUCTION CONSULTANT AND ARCHITECTURAL ENGINEER

Estimates and Appraisals

101 TREMONT STREET BOSTON, MASS.

THE COSMA LABORATORIES CO.

1545 East 18th Street Cleveland 14, Ohio

Chemical Analysis — Testing — Consulting Engineering
Testimony and Research

H. SEYMOUR COLTON, M.I.T. '21, *Director* — R. W. FRISCHMUTH, Case '38, *Assistant Director*

MORAN, PROCTOR, FREEMAN & MUESER
CONSULTING ENGINEERS

420 LEXINGTON AVENUE NEW YORK 17, N. Y.

Foundations for Buildings, Bridges and Dams; Tunnels, Bulkheads, Marine Structures, Soil Studies and Tests; Reports, Design and Supervision

Pardo, Proctor, Freeman & Mueser
Ingenieros Consultores
Ap. Correos 614, Caracas, Venezuela

WILLIAM H. MUESER, '22
GEORGE T. GILMAN, '23

PALMER RUSSELL CO.
Realtors

Real Estate Brokers — *Property Management*
Appraisals and Mortgages

1320 BEACON STREET BROOKLINE, MASS.

Edgar P. Palmer '25 — William W. Russell '22

FRANK MASSA
Electro-Acoustic Consultant

DEVELOPMENT — PRODUCTION DESIGN — PATENT ADVISOR

Loud Speakers — Microphones — Sound Powered Telephones
Supersonic Generators and Receivers
Electro-Acoustic Instruments
Underwater Sound

3393 DELLWOOD ROAD CLEVELAND HEIGHTS, OHIO

AREA PLACEMENT CHAIRMEN FOR MASSACHUSETTS INSTITUTE OF TECHNOLOGY

Each man listed below will have information about positions for M. I. T. Graduates who want to locate in his particular area

ALABAMA
ROBERT C. STOBERT '12, P. O. Drawer 1392, Birmingham

ARKANSAS
LESLIE A. JACKSON '09, Manager, Little Rock Municipal Water System, Little Rock

CALIFORNIA
EDWARD J. RILEY '09, Graybar Electric Company, Inc., Ninth and Howard Streets, San Francisco
FORD W. SAMMIS '28, 433 South Spring Street, Los Angeles 13

COLORADO
ALFRED E. PERLMAN '23, Denver and Rio Grande Western Railroad Company, Denver 1

CONNECTICUT
FREDERICK W. GREEN '32, Nash Engineering Company, Wilson Avenue, South Norwalk (Bridgeport area)
GEORGE L. MYLCHREEST '10, 238 Palm Street, Hartford
CHARLES E. SMITH '00, Railroad Office Building, New Haven

DISTRICT OF COLUMBIA
WILLIAM C. MEHAFFEY '17, 1630 North Greenbrier Street, Arlington, Virginia

FLORIDA
GEORGE W. SIMONS '15, Hildebrandt Building, Jacksonville
CLARENCE P. THAYER '23, 4212 N. W. Sixth Avenue, Miami
FRANKLIN O. ADAMS '07, 305 Morgan Street, Tampa

GEORGIA
WILLIAM E. HUGER '22, 11 Marietta Street, N.W., Atlanta 1

ILLINOIS
ROBERT W. CLYNE '30, American Steel Foundries, 400 North Michigan Ave., Chicago 11

INDIANA
FRANK C. BALKE '14, Balke and Krauss Company, 427 West Market Street, Indianapolis

KANSAS
FRED C. KOCH '22, Winkler-Koch Engineering Co., 335 West Lewis Street, Wichita

KENTUCKY
TINSLEY W. RUCKER III '31, The Crescent Panel Company, 32d and Market Streets, Louisville 12

LOUISIANA
THEODORE O. HOTARD '12, 221 Pelican Avenue, New Orleans 14

MAINE
FRANK A. KNIGHT '38, Eastern Corporation, Bangor
LEWIS D. NISBET '09, 44 Montrose Avenue, Portland

MARYLAND
GEORGE W. SPAULDING '21, 1605 Lexington Building, Baltimore 1

MASSACHUSETTS
ROBERT F. BURNETT '10, 85 North Main Street, Fall River
A. RUSSELL PIERCE, JR. '31, Palmer Scott Boatyard, New Bedford
LYNN WETHERILL '25, High Voltage Bushing Engineering Division, General Electric Company, 100 Woodlawn Avenue, Pittsfield
ALBERT D. KING '32, De Bell and Richardson, 3 Post Office Alley, Springfield

MICHIGAN
ADAM K. STRICKER '29, 1227 Bishop Road, Grosse Point Park, Detroit

MINNESOTA
LELAND CLAPPER '09, 5600 London Road, Duluth
CHARLES W. DREW '19, Minneapolis-Honeywell Regulator Company, Minneapolis

MISSOURI
HARRY L. HAVENS '09, Havens Structural Steel Company, 1713 Crystal, Kansas City
WESLEY W. WEDEMEYER '30, Wedemeyer and Hecker, Architects, 319 North Fourth Street, St. Louis 2

MONTANA
WALTER R. C. RUSSERT '18, Anaconda Copper Company, Butte

NEBRASKA
JOHN M. HANLEY '30, Northern Natural Gas Company, Aquila Court Building, Omaha

NEW HAMPSHIRE
BLAYLOCK ATHERTON '24, 142 Main Street, Nashua

NEW JERSEY
GEORGE A. CHUTTER '21, 109 Central Avenue, Glen Rock (Newark area)

NEW YORK
ANDREW F. ALLEN '12, State Department of Health, Albany
THOMAS H. SPELLER '29, General Engineering Company, 785 Hertel Avenue, Buffalo 7
JOHN C. FRUIT '02, Equitable Life Assurance Society of U. S., 393 7th Avenue, New York 1
RAYMOND G. BROWN '16, Comstock and Westcott Inc., Niagara Falls
C. KING CROFTON '22, 1132 Lincoln-Alliance Bank Building, Rochester 4
A. J. TACY '27, Room 645, Building No. 2, General Electric Company, Schenectady
J. MURRAY HASTINGS '13, 606 Hills Building, Syracuse

OHIO
JAMES B. HOLDEN '30, 276 Sundale Road, Akron
KENNETH A. WRIGHT '19, Johnson Service Company, 1905 Dunlap Street, Cincinnati 14
CHARLES B. ROWLEY '12, Charles Bacon Rowley and Associates, Keith Building, Cleveland
JAMES H. BLODGETT '20, Superintendent, Division of Sewage Treatment, Columbus
EUGENE HERZOG '27, 26 Cliff Street, Dayton
CHARLTON P. WHITTIER '27, Owens-Illinois Glass Company, P. O. Box 1035, Toledo 1

OKLAHOMA
W. J. SHERRY '21, 804 Kennedy Building, Tulsa

OREGON
ROBERT E. CUSHMAN '06, 618 N. W., Front Street, Portland 9

PENNSYLVANIA
PERCY TILLSON '06, 3003 North Front Street, Harrisburg
EDWARD J. HEALY '23, Philadelphia Brewing Company, 6th and Clearfield Streets, Philadelphia 33
HAROLD L. LANG '09, Carnegie Institute of Technology, Pittsburgh 13
G. C. WILSON '15 907 East King Street, Lancaster
LOUIS MORSE '96, York Corporation, Roosevelt Avenue, York

RHODE ISLAND
DONALD G. ROBBINS '07, c/o International Braid Company, 47 Charles Street, Providence

TENNESSEE
DANA M. WOOD '06, 619 Union Building, TVA, Knoxville
DONALD W. SOUTHGATE '11, Nashville Trust Building, Nashville 3

TEXAS
JONATHAN A. NOYES '12, 1914 Commerce Street, Dallas 1
JOSEPH H. McEVOY '21, 202 McGowen Avenue, Houston 6

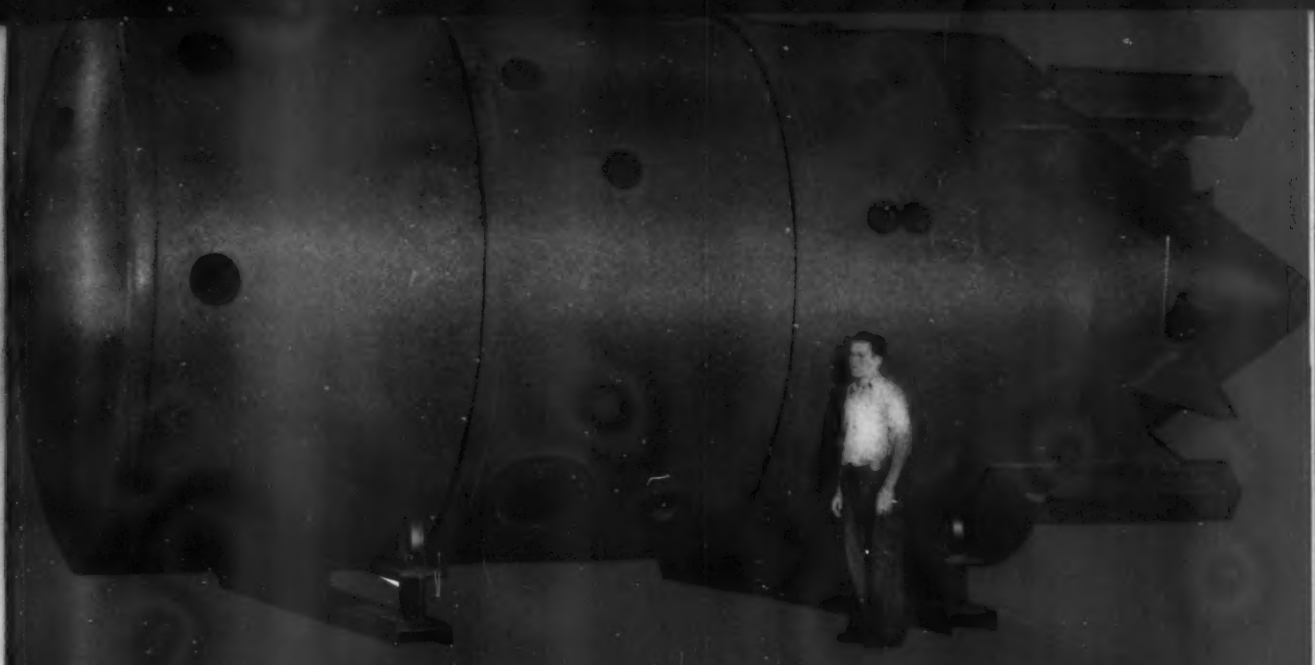
UTAH
GEORGE M. GADSBY '09, Utah Power and Light, Kearns Building, Salt Lake City

VIRGINIA
DONALD N. FRAZIER '11, 1226 Mutual Building, Richmond

WASHINGTON
HOLLAND H. HOUSTON '24, 215 Fifth Street, Olympia (Seattle area)
HOMER C. BENDER '09, 921 East 19th Street, Spokane

WISCONSIN
PHILIP N. CRISTAL '17, 720 East Wisconsin Avenue, Milwaukee 2

Placement Bureau • Massachusetts Institute of Technology • Cambridge 39, Mass.



GIANT RUBBER-LINED EVAPORATOR
Evaporator or Crystallizer for use in large Rayon Plant to recover valuable crystallized chemicals from processing solution, 10'6" dia. 28' long. Lined with Manhattan Acid-Resisting Rubber. Weight approximately 30,000 lbs. Used under 29" vacuum.

You Get a "Plus" of Quality in MANHATTAN Rubber Linings

THE WORLD'S LARGEST RUBBER-LINED NICKEL PLATING TANK, lined by Manhattan. Required 7 railroad flat cars to ship. Now in full operation with a large automatic elevator-type nickel plating conveyor.
(Photo courtesy Hanson-Van Winkle-Munning Company)

RUBBER-LINED EQUIPMENT FOR METAL PICKLING PLANT—Steel liquor sewers, fume exhaust ducts and stacks, drain piping and fittings all lined with Manhattan Acid-Proof Rubber Lining. For use in continuous strip pickling process in large steel mill. This part-shipment weighed 15 tons.

Companies engaged in the chemical processing and storing, metal finishing, plating and related industries have contributed in making Manhattan the foremost Rubber Lining manufacturer. Manhattan Rubber Linings are widely used on tanks, filters, impellers, mixers, agitators and troughs, blowers, exhaust fans and ducts, dipping cages, vacuum crystallizers, pipe and fittings, and on other equipment in endless variety of shapes.

Your 40-Year "Plus" at Manhattan

1- Experienced engineers and technique backed by 40 years of applying rubber to process handling equipment (53 years manufacturing other rubber products).

2- Development of a special rubber-to-metal bond that defies mechanical separation.

3- Compounding that will not crack or oxidize regardless of temperature changes and expansion or contraction of the metal.

4- Utmost resistance to blows and abrasion.

5- Enduring, dependable protection against corrosion and contamination.

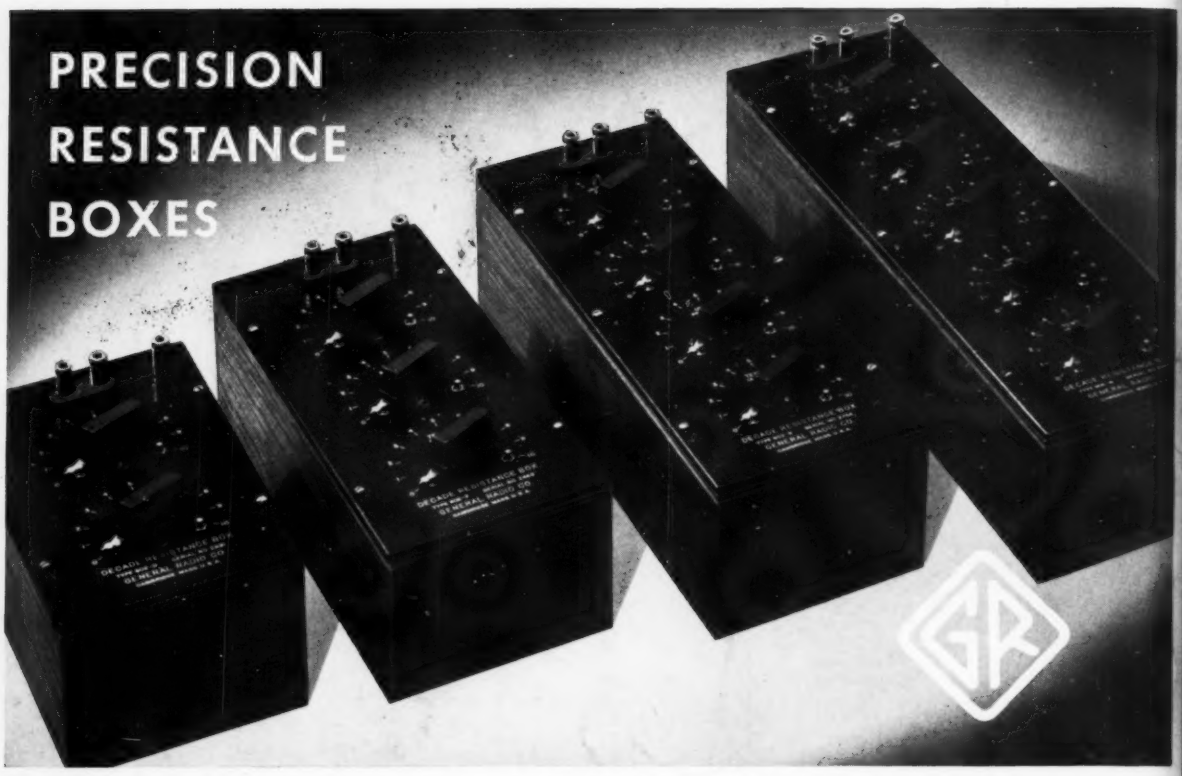
6- Elimination of stray currents.

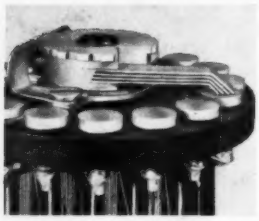
7- Extra long service and safety with resulting economies in handling most active acids, acid fumes, alkalies, salts, dye solutions and other caustic chemicals.

Protect Your Equipment—Lower Your Operating Costs
Consult Manhattan on corrosion and contamination jobs.

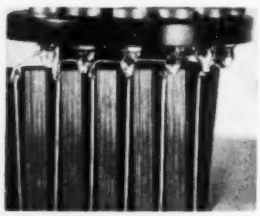
RAYBESTOS-MANHATTAN, INC.

MANHATTAN RUBBER DIVISION
EXECUTIVE OFFICES AND FACTORIES PASSAIC, NEW JERSEY

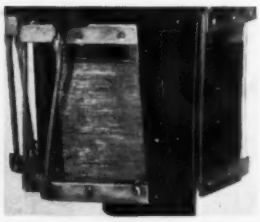




Quadruple-leaf, phosphor-bronze switches with wiping contact. Contact surfaces ground flat. Contact resistance only 0.002 ohm. Cam-type positive detent mechanism. Entire unit shielded behind panel.



Aryton-Perry windings of the 1-, 10-, and 100-ohm decades on bakelite cards.



Unifilar windings of the 1,000 and 10,000-ohm decades on mica cards.

● The General Radio Type 602 Decade-Resistance Boxes are universally accepted as the adjustable standards of resistance in laboratories where a wide range of resistance values is required.

FEATURES

- PERMANENT CALIBRATION
- THOROUGH AGING
- ACCURATELY ADJUSTED RESISTANCE VALUES
- LOW TEMPERATURE COEFFICIENT
- LOW INDUCTANCE AND CAPACITANCE WINDINGS
- NO APPRECIABLE FREQUENCY ERROR BELOW 50 KC
- LOW AND CONSTANT CONTACT RESISTANCE
- PROTECTED WINDINGS AND SWITCHES
- POSITIVE DETENT MECHANISMS
- SHIELDED CABINETS — NO BODY CAPACITANCE
- CURRENT-CARRYING CAPACITY ENGRAVED ON EACH DECADE
- NINE SIZES BETWEEN 0.1 TO 111 OHMS AND 1 TO 111, 110 OHMS
- MODERATELY PRICED BETWEEN $30 and $80

WE HAVE A FEW IN STOCK!

Write for Detailed Information and Complete Specifications

GENERAL RADIO COMPANY

275 MASSACHUSETTS AVENUE **CAMBRIDGE, MASSACHUSETTS**

BRANCHES: 90 West St., New York 6, 920 S. Michigan Ave., Chicago 5, 950 N. Highland Ave., Los Angeles 38

re
n
l.

Y
rs